

Marine Fish and Invertebrate Atlas: Summarizing Geographic Distribution and Population Indices in the Scotian Shelf and Bay of Fundy (1970-2020)

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2021

Canadian Technical Report of
Fisheries and Aquatic Sciences ####



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6 MARINE FISH AND INVERTEBRATE ATLAS: SUMMARIZING GEOGRAPHIC DISTRIBUTION,
7 POPULATION INDICES AND ENVIRONMENTAL PREFERENCES IN THE SCOTIAN SHELF
8 AND BAY OF FUNDY (1970-2020)

by

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²⁰ Cat. No. Fs97-6/nnnE-PDF ISBN ISSN 1488-5379

²¹ Correct citation for this publication:

²² Ricard, D., Gomez, C., Emberley, J. and Regnier-McKellar, C. 2021. Marine Fish and Invertebrate Atlas: Summarizing Geographic Distribution, Population Indices and Environmental Preferences in the Scotian Shelf and Bay of Fundy (1970-2020). Can. Tech. Rep. Fish. Aquat. Sci. nnn: viii + 192 p.

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ABSTRACT

167 Ricard, D., Gomez, C., Emberley, J. and Regnier-McKellar, C. 2021. Marine Fish and Invertebrate
168 Atlas: Summarizing Geographic Distribution, Population Indices and Environmental
169 Preferences in the Scotian Shelf and Bay of Fundy (1970-2020). Can. Tech. Rep. Fish. Aquat.
170 Sci. nnn: viii + 192 p.

171 The summer groundfish research vessel survey on the Scotian Shelf and in the Bay of
172 Fundy started in 1970 and was designed to measure the distribution and abundance of
173 major commercial fish species. Over time, additional information on non-commercial species
174 was collected, and allowed considerable insight into ecosystem function and structure, as
175 documented in many primary publications whose analyses used the survey data. The same
176 groundfish survey database has also been used to produce species status reports, atlases of
177 species distribution and remains an essential source of information for stock assessments in the
178 Maritimes Region of Fisheries and Oceans Canada. This report builds on previous work and
179 former atlases by updating a comprehensive suite of indices to assess population status and
180 environmental preferences of 104 species. For each species, trends in geographic distribution
181 and biomass or abundance were plotted. The spatial extent of distribution was plotted over
182 time to gauge how the area occupied has changed. The relationship between abundance or
183 biomass and spatial extent reflected whether the species distribution expands when abundance
184 or biomass increases. Length frequencies over time depicted any changes in mean size. The
185 plots of condition over time revealed whether individual fish are fatter or thinner than their long
186 term mean. Depth, temperature and salinity preferences were estimated to gauge the range
187 of suitable environmental parameters for each species. Finally, for each stratum, the slope
188 describing how local density varies with regional abundance was estimated. The reproducible
189 set of tools provided in this report constitutes a stepping stone to conduct other ecological
190 analyses using the summer groundfish research vessel survey data by fostering reproducibility
191 and transparency of ecological information collected and reported annually. Recognizing the
192 diversity of approaches for visualizing and mapping fish and invertebrates in the Scotian Shelf
193 bioregion, we recommend the development of a regional community of practice to compare and
194 evaluate approaches for mapping, interpolating and/or modelling fish and invertebrates so future
195 publications and advice can lead to more comparable work and consistent science advice to
196 support processes such as marine spatial planning.

RÉSUMÉ

198 Ricard, D., Gomez, C., Emberley, J. and Regnier-McKellar, C. 2021. Marine Fish and Invertebrate
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202 Le relevé estival par navires de recherche sur le poisson de fond sur le plateau néo-écossais
203 et dans la baie de Fundy a débuté en 1970 et visait à mesurer la répartition et l'abondance
204 des principales espèces de poissons commerciales. Au fil du temps, des informations
205 supplémentaires sur les espèces non commerciales ont été recueillies et ont permis de mieux
206 comprendre la fonction et la structure de l'écosystème, comme le montrent de nombreuses
207 publications primaires dont les analyses ont utilisé les données d'enquête. La même base
208 de données sur les relevés du poisson de fond a également été utilisée pour produire des
209 rapports sur la situation des espèces, des atlas de la répartition des espèces et demeure une
210 source essentielle d'information pour les évaluations des stocks dans la région des Maritimes
211 de Pêches et Océans Canada. Ce rapport s'appuie sur des travaux antérieurs et d'anciens
212 atlas en mettant à jour une série complète d'indices pour évaluer l'état de la population et les
213 préférences environnementales de 104 espèces. Pour chaque espèce, les tendances de la
214 répartition géographique et de la biomasse ou de l'abondance ont été tracées. L'étendue spatiale
215 de la distribution a été tracée au fil du temps pour évaluer comment la zone occupée a changé.
216 La relation entre l'abondance ou la biomasse et l'étendue spatiale indique si la répartition
217 des espèces augmente lorsque l'abondance ou la biomasse augmente. Les fréquences de
218 longueur au fil du temps représentaient tout changement dans la taille moyenne. Les graphiques
219 de l'état au fil du temps ont révélé si les poissons individuels sont plus gros ou plus minces
220 que leur moyenne à long terme. Les préférences en matière de profondeur, de température
221 et de salinité ont été estimées pour évaluer la gamme de paramètres environnementaux
222 appropriés pour chaque espèce. Enfin, pour chaque strate, la pente décrivant comment la
223 densité locale varie avec l'abondance régionale a été estimée. L'ensemble d'outils reproductibles
224 fournis dans ce rapport constitue un tremplin pour effectuer d'autres analyses écologiques
225 à l'aide des données du relevé estival des navires de recherche sur les poissons de fond
226 en favorisant la reproductibilité et la transparence de l'information écologique recueillie et
227 rapportée annuellement. Reconnaissant la diversité des approches de visualisation et de
228 cartographie des poissons et des invertébrés dans la biorégion du plateau néo-écossais, nous
229 recommandons le développement d'une communauté de pratique régionale pour comparer et
230 évaluer les approches de cartographie, d'interpolation et / ou de modélisation des poissons
231 et des invertébrés afin conduire à des travaux plus comparables et à des avis scientifiques
232 cohérents pour soutenir des processus tels que la planification de l'espace marin.

233

1 Introduction

234 The summer (July-August) groundfish research vessel survey on the Scotian Shelf and in the
235 Bay of Fundy was started in 1970 by Fisheries and Oceans Canada Maritimes Region. The
236 survey was originally designed to measure the distribution and abundance of major commercial
237 fish species. Over time, information on non-commercial species was also collected. The
238 groundfish survey database storing the information collected during the annual survey provides
239 the main source of fisheries-independent information for marine species in the region. This
240 information is routinely used to support stock assessments, to produce species status reports
241 and has been previously used to publish atlases of species distribution.

242 The current document is an update of an earlier report (Ricard and Shackell 2013) that built
243 on former atlases by updating a comprehensive suite of derived indices for 104 species to
244 assess population status and, when feasible, environmental preferences. The information
245 collected during the survey is stored in a relational database management system archived
246 at Fisheries and Oceans Canada Maritimes Region which contains detailed information about
247 the sampling locations and the associated catch. Tow-level survey data is also publicly available
248 from the Ocean Biogeographic Information System (DFO 2016) and from the Open data portal
249 supported by the federal government (DFO 2021). The present atlas builds upon the work done
250 by Fisheries and Oceans colleagues from the northern Gulf of St. Lawrence (Bourdages and
251 Ouellet 2012), southern Gulf of St. Lawrence (Benoît et al. 2003) and on earlier work in the
252 Scotian Shelf (Simon and Comeau 1994; Horsman and Shackell 2009).

253 To facilitate updates and foster collaboration on the analyses of the survey data, the computer
254 code necessary to extract the data, to perform the analyses presented herein, and to reproduce
255 and update the current document is made available in a git repository (Ricard and Gomez 2021).

256 The survey area covers three major Northwest Atlantic Fisheries Organization (NAFO) zones
257 that divide the Scotian Shelf into the colder east 4V and 4W (strata 440-466) and warmer
258 west 4X (strata 470-495). For each species, temporal trends in geographic distribution and,
259 when possible, biomass are plotted. Some caution is required in interpreting the results
260 obtained for several taxa due to low sample size as explained later in the text. A full ecological
261 interpretation of trends is beyond the scope of this report. Other documents stemming from peer-
262 reviewed scientific processes under the auspices of the [Canadian Science Advisory Secretariat](#)
263 (CSAS) provide further descriptions of spatio-temporal trends in different indicators and put the
264 information collected during the summer groundfish research vessel survey in a more focused
265 context (see for example Clark and Emberley (2011)).

266

2 Methods

267 2.1 Survey Description

268 The survey is conducted annually in July-August and covers the Scotian Shelf and the Bay of
269 Fundy (Figure 2). It normally involves two separate two-week trips on board an offshore fisheries
270 vessel from the Canadian Coast Guard.

271 A number of changes in fishing gear type and vessels used occurred since the onset of sampling
272 activities (Clark and Emberley 2011). Comparative fishing experiments were conducted when
273 those changes in survey platforms took place. A timeline of the survey platforms can be found in
274 Figure 1.

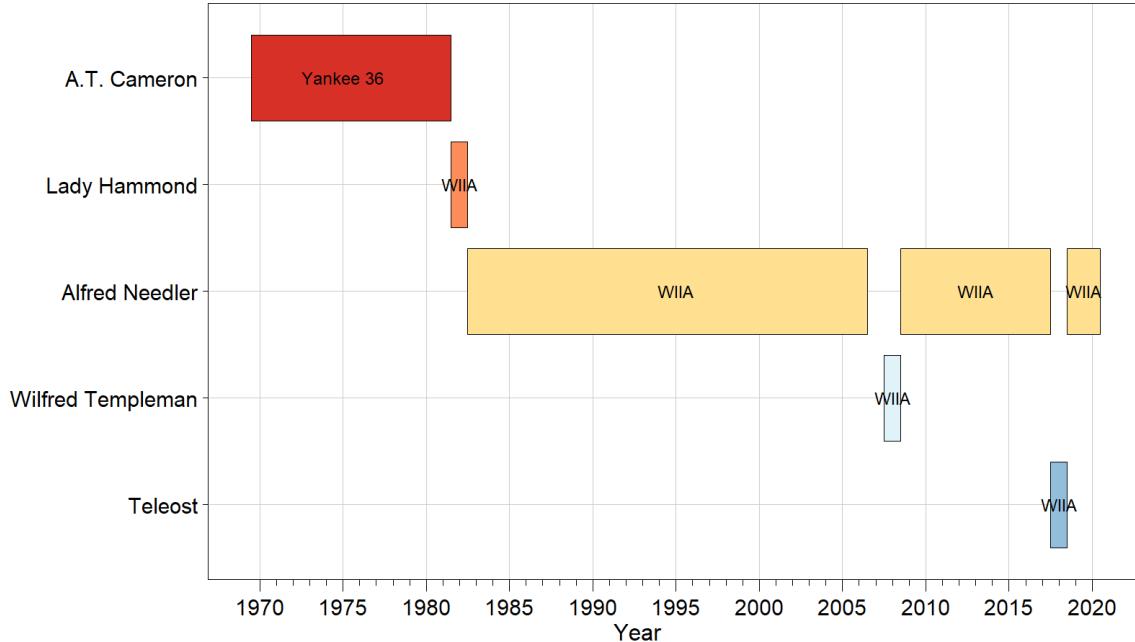


Figure 1. Timeline of vessels and gears used in the Maritimes Region summer survey. Comparative fishing experiments are indicated by gray bars linking two fishing platforms.

275 2.2 Sampling Design

276 The summer survey covers divisions 4V, 4W and 4X of the Northwest Atlantic Fisheries
277 Organization (NAFO) which includes the Scotian Shelf and the Bay of Fundy. The eastern limit of
278 the survey is the Laurentian Channel and the western limit is the Fundian Channel (Figure 2).

279 The survey follows a stratified random design (Doubleday and Rivard 1981; Lohr 1999)
280 (Figure 3). The number of tows conducted in each stratum is approximately proportional to the
281 surface area of the stratum. The targeted area covered by the survey has remained constant
282 since its inception, with the exception of additional deeper strata that were only sampled a few
283 times since 2000. Because the sampling of the deeper strata is opportunistic and irregular, the
284 analyses presented herein only include strata 440 to 495 which cover NAFO Divisions 4V, 4W
285 and 4X (Figure 3 and Table 1).

286 The basic sampling unit of the survey is a 30-minute fishing tow conducted at a speed of 3.5
287 knots. This yields a distance towed of 1.75 nautical miles.

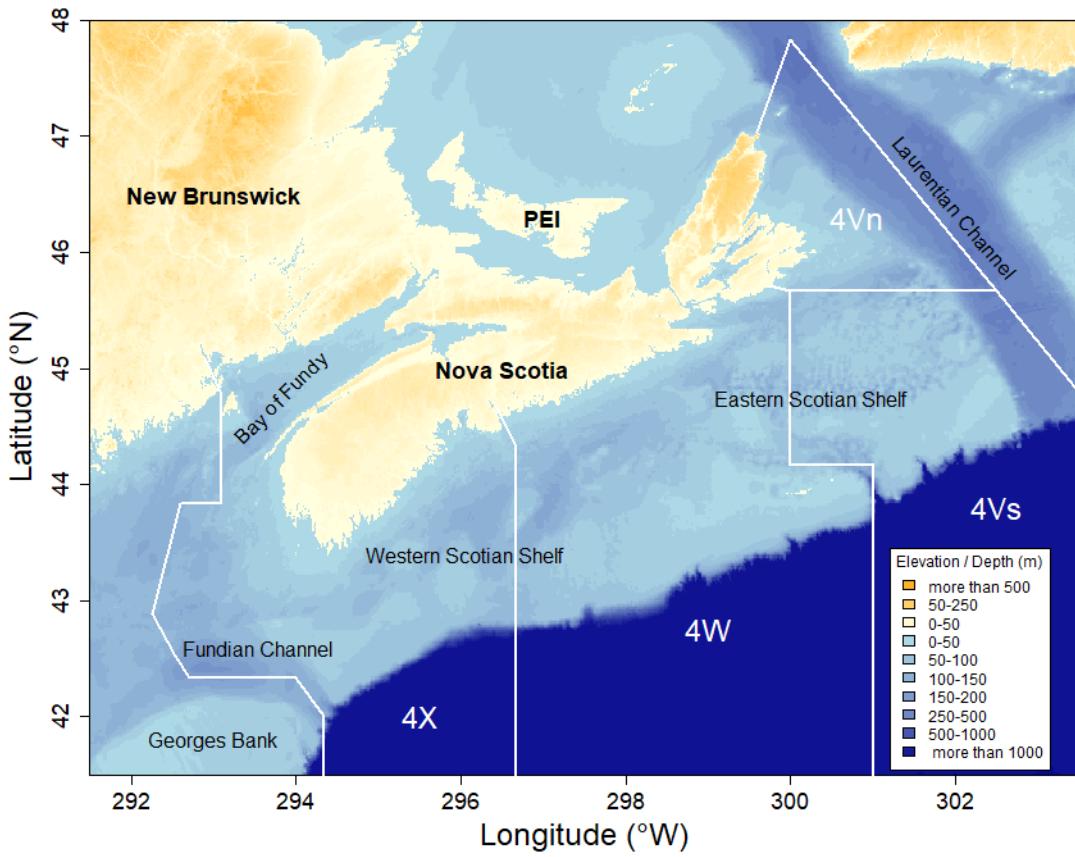


Figure 2. Map of the Scotian Shelf and Bay of Fundy where the DFO Maritimes summer survey takes place. The bathymetry presented here is the 15 arc-second gridded data set from the General Bathymetric Chart of the Oceans ([GEBCO](#)). Geographical locations of interest and the boundaries of relevant NAFO Divisions are also shown on the map.

Table 1. Summer survey strata details. The strata used in the analyses are presented separately for NAFO Divisions 4Vn, 4VsW and 4X. For each stratum, the depth range in fathoms and the surface area in square kilometers are reported.

NAFO Div.	Stratum	Depth range (fathom)	Area (km ²)
4Vn	440	101-200	924
	441	51-100	1000
	442	11-49	1437

NAFO Div.	Stratum	Depth range (fathom)	Area (km²)
4VsW	443	11-49	1318
	444	51-100	3925
	445	101-200	1023
	446	101-200	491
	447	11-49	1616
	448	11-49	1449
	449	51-100	144
	450	51-100	383
	451	101-200	147
	452	101-200	345
	453	101-200	259
	454	51-100	499
	455	11-49	2122
	456	11-49	955
	457	51-100	811
	458	11-49	658
	459	11-200	3148
	460	51-100	1344
	461	101-200	1154
	462	51-100	2116
	463	11-49	302
	464	11-50	1297
	465	51-100	2383
	466	101-200	226

NAFO Div.	Stratum	Depth range (fathom)	Area (km ²)
4X	470	51-100	920
	471	101-200	1004
	472	51-100	1249
	473	11-49	265
	474	11-49	161
	475	11-49	156
	476	51-100	1478
	477	51-100	1232
	478	101-200	233
	480	11-49	655
	481	51-100	1875
	482	101-200	1042
	483	101-200	532
	484	101-200	2264
	485	51-100	1582
	490	11-49	601
	491	51-100	687
	492	51-100	1086
	493	11-49	533
	494	11-49	417
	495	11-49	584

288 After each tow the catch is sorted by species and weighed. Each fish caught is then measured,
 289 and further sampling of individual fish weight, maturity status and age are performed for different
 290 length classes. When catches exceed 300 individuals, a random sub-sample is used to obtain
 291 the length and weight measurements.

292 2.3 Taxonomic Levels

293 Fish species caught during the surveys are identified by trained scientific personnel and their
 294 scientific name is determined. An internal species code used in the relational database is
 295 reported for each species (Losier and Waite 1989).

296 By its nature as a bottom trawl, the fishing gear used in the survey catches certain species
 297 better than others. To ensure that meaningful ecological information can be extracted from
 298 catch samples, we report the catch records for the subset of species that are caught reliably
 299 by the gear. To appear in this atlas, a species must have had a minimum of 10 observations over
 300 the duration of the survey activities. While both catch abundance and weight are recorded, the
 301 weight of species that appear at low abundances is often recorded as zero in the earlier parts of
 302 the survey when scales of appropriate precision were not available.

303 We divided the species caught into five categories based on 1) their taxonomic classification,

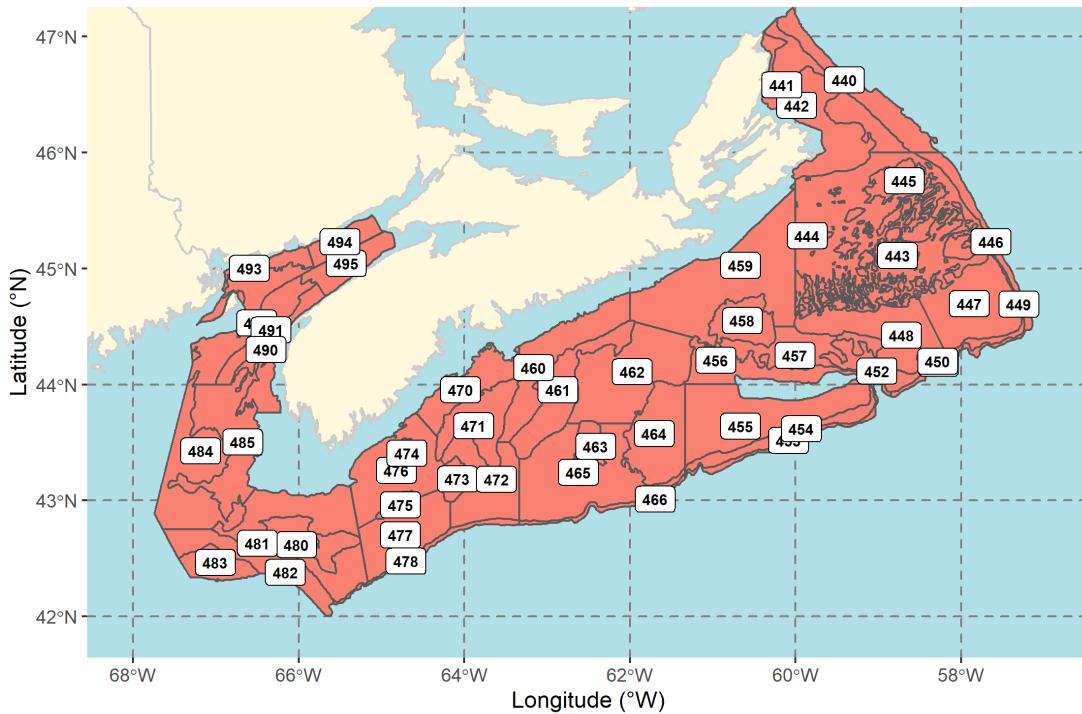


Figure 3. Map of the summer survey strata 440 to 495.

304 2) the number of recorded observations, and 3) their period of valid identification (Table 2).
 305 Category "LF", for "long frequent", was assigned to species that have more than 1000 records
 306 since 1970 and have been consistently identified since the onset of the survey. Category
 307 "LI", for "long intermediate", was assigned to species that had between 1000 and 200 catch
 308 records. Rare and elusive species (those with less than 200 catch records over the duration
 309 of the survey) are also reported but to a lower level of analytical details (Category "LR", for
 310 "long rare"). Category "SF", for "short frequent", was assigned to invertebrate species that were
 311 consistently sampled only since 1999 (Tremblay M. J. 2007). And category "SR", for "short rare"
 312 for invertebrate species consistently sampled only since 1999 and with less than 200 catch
 313 records. To ensure concordance with authoritative taxonomic information, the AphiaID from the

Table 2. Taxonomic levels used to determine the analytical treatment for each species.

Category	Name	Description
L	long - consistently identified since the onset of the survey in 1970	
LF	long frequent	species that have more than 1000 catch records
LI	long intermediate	species that had between 1000 and 200 catch records
LR	long rare	species with less than 200 catch records
S	short - invertebrate species that were consistently sampled only since 1999	
SF	short frequent	species with more than 200 catch records
SR	short rare	species with less than 200 catch records

³¹⁴ World Register of Marine Species (Appeltans et al. 2012) is included for the different species
³¹⁵ presented in this document (Table 3) .

Table 3. List of species included in the Atlas. For each taxonomic order and class, each species is listed in the table, its taxonomic family and scientific name is provided, along with its French and English common names, the species code used in the survey database, its AphiaID with a link to the World Registry of Marine Species, its number of catch records in the survey database and its classification category as defined in section 2.3.

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Actinopterygii								
<i>Anguilliformes</i>								
	Nemichthyidae	<i>Nemichthys scolopaceus</i>	Slender snipe eel	Avocette ruban	604	126306	28	LR
<i>Argentiniformes</i>								
	Argentinidae	<i>Argentina silus</i>	Greater argentine	Grande argentine	160	126715	963	LI
<i>Aulopiformes</i>								
	Chlorophthalmidae	<i>Chlorophthalmus agassizi</i>	Shortnose greeneye	Éperlan du large	156	126336	78	LR
		<i>Parasudis truculenta</i>	Longnose greeneye	Oeil-vert à long nez	149	158868	45	LR
	Paralepididae	<i>Arctozenus risso</i>	White barracudina	Lussion blanc	712	126352	196	LR
<i>Beloniformes</i>								
	Scomberesocidae	<i>Scomberesox saurus</i>	Atlantic saury	Balaou atlantique	720	126392	37	LR
<i>Clupeiformes</i>								
	Clupeidae	<i>Alosa pseudoharengus</i>	Alewife	Gaspareau	62	158669	977	LI
		<i>Alosa sapidissima</i>	American shad	Alose savoureuse	61	158670	468	LI
		<i>Clupea harengus</i>	Atlantic herring	Hareng de l'Atlantique	60	126417	3487	LF
<i>Gadiformes</i>								
	Gadidae	<i>Gadus morhua</i>	Atlantic cod	Morue franche	10	126436	5451	LF
		<i>Melanogrammus aeglefinus</i>	Haddock	Aiglefin	11	126437	5827	LF
		<i>Microgadus tomcod</i>	Atlantic tomcod	Poulamon atlantique	17	158928	44	LR
		<i>Pollachius virens</i>	Pollock	Goberge	16	126441	2787	LF
	Lotidae	<i>Brosme brosme</i>	Cusk	Brosme	15	126447	688	LI

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Perciformes	Macrouridae		<i>Enchelyopus cimbricus</i>	Fourbeard rockling	Motelle à quatre barbillons	114	126450	693	LI
			<i>Coryphaenoides rupestris</i>	Roundnose grenadier	Grenadier de roche	414	158960	17	LR
			<i>Nezumia bairdii</i>	Marlin-spike grenadier	Grenadier du Grand Banc	410	183289	529	LI
			<i>Trachyrincus murrayi</i>	Roughnose grenadier	Grenadier-scie	412	126481	18	LR
	Merlucciidae		<i>Merluccius albidus</i>	Offshore silver hake	Merlu argenté du large	19	158748	161	LR
			<i>Merluccius bilinearis</i>	Silver hake	Merlu argenté	14	158962	4936	LF
	Phycidae		<i>Phycis chesteri</i>	Longfin hake	Merluche à longues nageoires	112	158988	784	LI
			<i>Urophycis chuss</i>	Red hake	Merluche écureuil	13	126503	2195	LF
			<i>Urophycis tenuis</i>	White hake	Merluche blanche	12	126504	3524	LF
<i>Lophiiformes</i>	Lophiidae	<i>Lophius americanus</i>	Monkfish	Baudroie d'Amérique	400	159184	1970	LF	
	Ogcocephalidae	<i>Dibranchus atlanticus</i>	Atlantic batfish	Malthe atlantique	742	126558	18	LR	
	Myctophidae	<i>Myctophidae</i>	Lanternfishes	Poissons-lanternes	150	125498	160	LR	
<i>Osmeriformes</i>	Osmeridae		<i>Mallotus villosus</i>	Capelin	Capelan	64	126735	540	LI
			<i>Osmerus mordax</i>	Rainbow smelt	Éperlan arc-en-ciel	63	126737	59	LR
	Ammodytidae	<i>Ammodytes dubius</i>	Sand lance	Lançon	610	151520	1283	LI	
<i>Anarhichadidae</i>			<i>Anarhichas denticulatus</i>	Northern wolffish	Loup à tête large	52	126757	17	LR
			<i>Anarhichas lupus</i>	Atlantic wolffish	Loup atlantique	50	126758	1572	LF

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
			<i>Anarhichas minor</i>	Spotted wolffish	Loup tacheté	51	126759	20	LR
		Callionymidae	<i>Foetorepus agassizii</i>	Spotfin dragonet	Dragonnet tacheté	637	276339	20	LR
		Cryptacanthodidae	<i>Cryptacanthodes maculatus</i>	Wrymouth	Terrassier tacheté	630	159675	120	LR
		Labridae	<i>Tautogolabrus adspersus</i>	Cunner	Tanche-tautogue	122	159785	82	LR
		Pholidae	<i>Pholis gunnellus</i>	Rock gunnel	Sigouine de roche	621	126996	21	LR
		Scombridae	<i>Scomber scombrus</i>	Atlantic mackerel	Maquereau commun	70	127023	696	LI
		Stichaeidae	<i>Eumesogrammus praecisus</i>	Fourline snakeblenny	Quatre-lignes atlantique	626	159817	40	LR
			<i>Leptoclinus maculatus</i>	Daubed shanny	Lompénie tachetée	623	127072	443	LI
			<i>Lumpenus lampretaeformis</i>	Snakeblenny	Lompénie-serpent	622	154675	423	LI
			<i>Ulvaria subbifurcata</i>	Radiated shanny	Ulvaire deux-lignes	625	159821	145	LR
		Stromateidae	<i>Peprilus triacanthus</i>	Atlantic butterfish	Stromaté fossette	701	159828	487	LI
		Zoarcidae	<i>Lycenchelys verrillii</i>	Wolf eelpout	Lycode à tête longue	603	159258	40	LR
			<i>Lycodes lavalaei</i>	Newfoundland eelpout	Lycode du Labrador	620	127107	72	LR
			<i>Lycodes reticulatus</i>	Arctic eelpout	Lycode arctique	641	127112	70	LR
			<i>Lycodes terraenovae</i>	Newfoundland eelpout	Lycode du Labrador	619	127117	64	LR
			<i>Lycodes vahlii</i>	Vahl's eelpout	Lycode à carreaux	647	127118	565	LI
			<i>Melanostigma atlanticum</i>	Atlantic soft pout	Molasse atlantique	646	127120	43	LR
			<i>Zoarces americanus</i>	Ocean pout	Loquette d'Amérique	640	159267	1478	LF
<i>Pleuronectiformes</i>		Cynoglossidae	<i>Syphurus diomedeanus</i>	Spottedfin tonguefish	Langue fil noir	816	159358	24	LR

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Paralichthyidae	<i>Citharichthys arctifrons</i>	Gulf Stream flounder	Plie du Gulf Stream	44	158791	382	LI
			<i>Hippoglossina oblonga</i>	Fourspot flounder	Cardeau à quatre ocelles	142	158833	76	LR
		Pleuronectidae	<i>Glyptocephalus cynoglossus</i>	Witch flounder	Plie grise	41	127136	4301	LF
			<i>Hippoglossoides platessoides</i>	American plaice	Plie canadienne	40	127137	6023	LF
			<i>Hippoglossus hippoglossus</i>	Atlantic halibut	Flétan de l'Atlantique	30	127138	1634	LF
			<i>Limanda ferruginea</i>	Yellowtail flounder	Limande à queue jaune	42	158879	3233	LF
			<i>Pseudopleuronectes americanus</i>	Winter flounder	Limande-plie rouge	43	158885	1632	LF
			<i>Reinhardtius hippoglossoides</i>	Greenland halibut	Flétan noir	31	127144	736	LI
		Scophthalmidae	<i>Scophthalmus aquosus</i>	Windowpane flounder	Turbot de sable	143	158907	115	LR
Scorpaeniformes	Agonidae		<i>Agonidae</i>	Alligatorfishes	Poissons-alligator	351	125588	43	LR
			<i>Aspidophoroides monopterygius</i>	Alligatorfish	Poisson-alligator atlantique	340	159459	1029	LF
			<i>Leptagonus decagonus</i>	Atlantic poacher	Agone atlantique	350	127191	266	LI
			<i>Ulcina olrikii</i>	Arctic alligatorfish	Poisson-alligator arctique	341	274356	13	LR
	Cottidae		<i>Artediellus atlanticus</i>	Atlantic hookear sculpin	Hameçon atlantique	880	127193	258	LI
			<i>Artediellus uncinatus</i>	Arctic hookear sculpin	Hameçon neigeux	306	127195	306	LI

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Perciformes	Triglidae		<i>Icelus spatula</i>	Spatulate sculpin	lcèle spatulée	314	127200	40	LR
			<i>Myoxocephalus aenaeus</i>	Grubby	Chabosseau bronzé	303	159519	40	LR
			<i>Myoxocephalus octodecemspinosus</i>	Longhorn sculpin	Chabosseau à dix-huit épines	300	159520	3292	LF
			<i>Myoxocephalus scorpius</i>	Shorthorn sculpin	Chabosseau à épines courtes	301	127203	131	LR
			<i>Triglops murrayi</i>	Moustache sculpin	Faux-trigle armé	304	127205	1182	LF
	Cyclopteridae		<i>Cyclopterus lumpus</i>	Lumpfish	Lompe	501	127214	216	LI
			<i>Eumicrotremus spinosus</i>	Atlantic spiny lumpucker	Petite poule de mer atlantique	502	127217	226	LI
	Hemitripteridae		<i>Hemitripterus americanus</i>	Sea raven	Hémithriptère atlantique	320	159518	2126	LF
	Liparidae		<i>Careproctus reinhardtii</i>	Sea tadpole	Petite limace de mer	520	127212	18	LR
			<i>Liparis atlanticus</i>	Atlantic seasnail	Limace atlantique	503	159524	34	LR
			<i>Liparis fabricii</i>	Gelatinous snailfish	Limace gélatineuse	505	127218	27	LR
			<i>Liparis gibbus</i>	Variegated snailfish	Limace marbée	512	159526	41	LR
Stomiiformes	Psychrolutidae		<i>Cottunculus microps</i>	Polar sculpin	Cotte polaire	307	127235	29	LR
	Sebastidae		<i>Helicolenus dactylopterus</i>	Blackbelly rosefish	Sébaste chèvre	123	127251	610	LI
			<i>Sebastes</i>	Atlantic redfishes	Sébastes de l'Atlantique	23	126175	4152	LF
	Sternopychidae		<i>Maurolicus muelleri</i>	Silvery lightfish	Brossé améthyste	158	127312	52	LR
			<i>Sternopychidae</i>	Hatchetfishes	Haches d'argent	741	125603	21	LR
	Stomiidae		<i>Stomias boa</i>	Boa dragonfish	Dragon-boa	159	127374	20	LR
<i>Zeiformes</i>									

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Zeidae	<i>Zenopsis conchifer</i>	Silvery John dory	Saint Pierre argenté	704	127426	39	LR
Cephalopoda									
<i>Myopsida</i>									
		Loliginidae	<i>Doryteuthis pealeii</i>	Longfin inshore squid	Calmar totam	4512	574541	96	LR
<i>Oegopsida</i>									
		Ommastrephidae	<i>Illex illecebrosus</i>	Northern shortfin squid	Encornet rouge nordique	4511	153087	4836	LF
Elasmobranchii									
<i>Rajiformes</i>									
		Rajidae	<i>Amblyraja radiata</i>	Thorny skate	Raie épineuse	201	105865	3937	LF
			<i>Dipturus laevis</i>	Barndoor skate	Grande raie	200	158548	246	LI
			<i>Leucoraja erinacea</i>	Little skate	Raie hérisson	203	158551	712	LI
			<i>Leucoraja ocellata</i>	Winter skate	Raie tachetée	204	158553	1180	LF
			<i>Malacoraja senta</i>	Smooth skate	Raie lisse	202	158554	1773	LF
<i>Squaliformes</i>									
		Etmopteridae	<i>Centroscyllium fabricii</i>	Black dogfish	Aiguillat noir	221	105906	31	LR
		Squalidae	<i>Squalus acanthias</i>	Piked dogfish	Aiguillat commun	220	105923	1985	LF
Malacostraca									
<i>Decapoda</i>									
		Cancridae	<i>Cancer borealis</i>	Jonah crab	Tourteau jona	2511	158056	1387	SF
			<i>Cancer irroratus</i>	Atlantic rock crab	Tourteau poïnclos	2513	158057	788	SF
		Geryonidae	<i>Chaceon quinquedens</i>	Red deepsea crab	Crabe rouge	2532	158407	33	SR
		Lithodidae	<i>Lithodes maja</i>	Atlantic king crab	Crabe épineux du nord	2523	107205	531	SF
		Nephropidae	<i>Homarus americanus</i>	American lobster	Homard américain	2550	156134	1623	SF

Class	Order	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Oregoniidae			<i>Chionoecetes opilio</i>	Queen crab	Crabe des neiges	2526	107315	1546	SF
			<i>Hyas araneus</i>	Great spider crab	Crabe lyre araignée	2527	107322	625	SF
			<i>Hyas coarctatus</i>	Arctic lyre crab	Crabe Hyas coarctatus	2521	107323	711	SF
		Pandalidae	<i>Pandalus borealis</i>	Northern prawn	Crevette nordique	2211	107649	718	SF
Myxini									
<i>Myxiniformes</i>									
		Myxinidae	<i>Myxine glutinosa</i>	Atlantic hagfish	Myxine du nord	241	101170	804	LI
Petromyzonti									
<i>Petromyzontiformes</i>									
		Petromyzontidae	<i>Petromyzon marinus</i>	Sea lamprey	Lamproie marine	240	101174	16	LR

316 **2.4 Analyses**

317 The Oracle relational database where all survey data are stored and archived is accessible from
318 the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Queries written in Structured
319 Query Language (SQL) are used to extract the data from the production server and to create the
320 data products used in all subsequent analyses. Catch records classified as "valid" (i.e. coming
321 from a representative tow without damage to the net) are used in the current analyses. To make
322 the available samples comparable, catch number and weight for each species was standardized
323 for the distance towed.

324 All data processing and analyses were conducted using the R software (R Core Team 2020)
325 using packages gstat (Pebesma 2004), PBSmapping (Schnute et al. 2019), RODBC (Ripley
326 and Lapsley 2019), spatstat (Baddeley 2015), maptools (Bivand and Lewin-Koh 2020), rgeos
327 (Bivand and Rundel 2020), classInt(Bivand 2020), RColorBrewer(Neuwirth 2014), MASS (Ripley
328 et al. 2020), worms (Holstein 2018), and tidyverse (Wickham 2019). The present document is
329 rendered as a Technical Report using the csasdown R package developed and maintained by
330 Fisheries and Oceans Canada scientists (Anderson et al. 2021).

331 **2.4.1 Geographic distribution of catches**

332 Spatial interpolation of catch biomass (kg/tow) was done using a weighting inversely proportional
333 to the distance (inverse-distance weighted, IDW), using function "idw" of the spatstat R package
334 (Baddeley 2015). The IDW method was used with a power parameter value of 10.

335 **2.4.2 Biomass indices**

336 For each species, stratified random estimates of catch biomass (Smith 1996) were computed for
337 each year. Yearly estimates of the standard error were also computed.

338 **2.4.3 Distribution indices**

339 For each Category L, I and S fish species, the minimum area required to account for 75% and
340 95% of the total biomass were computed (D75% and D95%). These measures of distributions
341 were computed for each year by using the Lorenz curve of mean stratum-level catch estimates
342 and the area of occupied strata (Swain and Sinclair 1994; Swain and Morin 1996).

343 **2.4.4 Length frequencies**

344 The length frequency distribution of catch (the stratified numbers-at-length) is tabulated for each
345 seven-year period (1970-2009), and last ten-year period (2010-2020).

346 **2.4.5 Length-weight relationship and condition factor**

347 The relationship between the weight and the length of fish was estimated using the following
348 non-linear isometric relationship:

$$W = \alpha L^\beta$$

349 where W is the total weight (g), L is the length (cm), and, α and β are the parameters to be
350 estimated.

351 Average fish condition (C) was computed as:

$$C = \frac{W}{\alpha L^\beta}$$

352

353 **2.4.6 Depth, temperature and salinity distribution of catches**

354 For each category L species, We followed the methods developed by (Perry and Smith 1994)
355 and generated cumulative frequency distributions of depth, temperature and salinity of survey
356 catches.

357 **2.4.7 Density-dependent habitat selection**

358 We followed the methods of (Myers and Stokes 1989) to evaluate how fish abundance in each
359 stratum varied with overall temporal fluctuations of population abundance.

360 For each category L species, we fitted a model of the relationship between stratum-level density
361 and overall abundance (the yearly stratified random estimate of abundance, defined above).
362 To properly use the observations of zero catch while accounting for the logarithmic distribution
363 of catch abundance, we implemented the model as a generalised linear using a log link and a
364 Poisson error distribution:

$$Y_{h,i} = \alpha_{h,i} Y_i^{\beta_{h,i}}$$

365 where, $y_{h,i}$ is the average abundance of stratum h in year i , and $\alpha_{h,i}$ and $\beta_{h,i}$ are the fitted
366 parameters. The estimated parameter $\beta_{h,i}$ is referred to as the “slope parameter” and indicates
367 whether stratum-level density is positively ($\beta_{h,i} <= 0$), negatively ($\beta_{h,i} >= 0$) or negligibly
368 ($\beta_{h,i} \approx 0$) related to population abundance.

369 To estimate the suitability of each stratum, the median abundance observed during the years
370 that are in the top 25% of yearly estimates is used. We combine the slope parameter estimates
371 from the above model with the median abundance to identify strata that have consistently high
372 abundance and whose local density is weakly related to fluctuation in population abundance
373 ($\beta_{h,i} \approx 0$). Preferred strata are identified for each category L species.

374 **2.5 Description of Figures**

375 **2.5.1 Type A**

376 For Category L and S species:

377 Spatial distribution of catch-per unit of effort, (CPUE, kilograms per tow) in July-August for the
378 Bay of Fundy and Scotian Shelf in five-year periods. Spatial interpolation between tows was
379 done using Inverse Distance Weight (IDW). The probability of occurrence (proportion of tows with
380 catch records for a given species) was also reported for each five-year period.

381 For Category LR and SR:

382 Location of tows with catch over the period 1970-2020 (Type LR) or the period 1999-2020 (Type
383 SR). Location of tows with catch over the period 1970-2020 (Type LR) or the period 1999-2020
384 (Type SR).

385 **2.5.2 Type B**

386 For Category L, S and I species:

387 Stratified random estimate of CPUE (left panel), distribution indices (D75% and D95%, the
388 minimum area containing 75% and 95% of biomass, middle panel), and distribution vs. weight
389 per tow (right panel). The stratified random mean is plotted as a solid line with the 95%
390 confidence region indicated by the solid grey line. The overall mean is plotted as a grey
391 horizontal line and the overall mean plus or minus 50% of the standard deviation appear as
392 horizontal dashed lines. In all three panels, the early years appear in blue and the last years
393 appear in red. The predictions from a loess estimator are overlaid on the distribution indices
394 (middle panel). The Pearson correlation coefficient between D75% and biomass, and its
395 statistical significance, are also reported in the right panel.

396 **2.5.3 Type C.**

397 Length frequency distribution for NAFO divisions 4X and 4VW. A smoothed length frequency
398 distribution is shown for each 7-year periods covered by the surveys.

399 **2.5.4 Type D.**

400 Average fish condition for all fish lengths (black dots and black line), large fish (thick gray line),
401 and small fish (thin gray line). Fish condition is presented for NAFO divisions 4VW (right panel)
402 and 4X (left panel).

403 **2.5.5 Type E.**

404 Cumulative frequency distributions of depth, temperature and salinity at all sampled locations
405 (thick solid line) and at fishing locations with catch records (thin dashed line). The depth,
406 temperature and salinity associated with 5%, 25%, 50%, 75% and 95% of the cumulative catch is
407 shown in tabular fashion on the bottom right panel.

408 **2.5.6 Type F.**

409 Slopes estimates from the density-dependent habitat selection model (y axis) plotted versus
410 the median abundance during the top 25% of years. The red box indicates strata of particular
411 importance for a species by identifying slopes that are within a standard error from zero and that
412 are within the top 25% of median abundance. Each stratum is identified on the plot by the last
413 two digits of its number.

414 **3 Results**

415 The plots generated for each species are presented in the Appendix.

416 **3.1 Summary of successful tows by year and stratum**

417 A total of 9080 representative tows were conducted for the period spanning from 1970 to 2020
418 (Figure 4).

419 Tables 4, 5 and 6 present the number of tows conducted in each stratum and year.

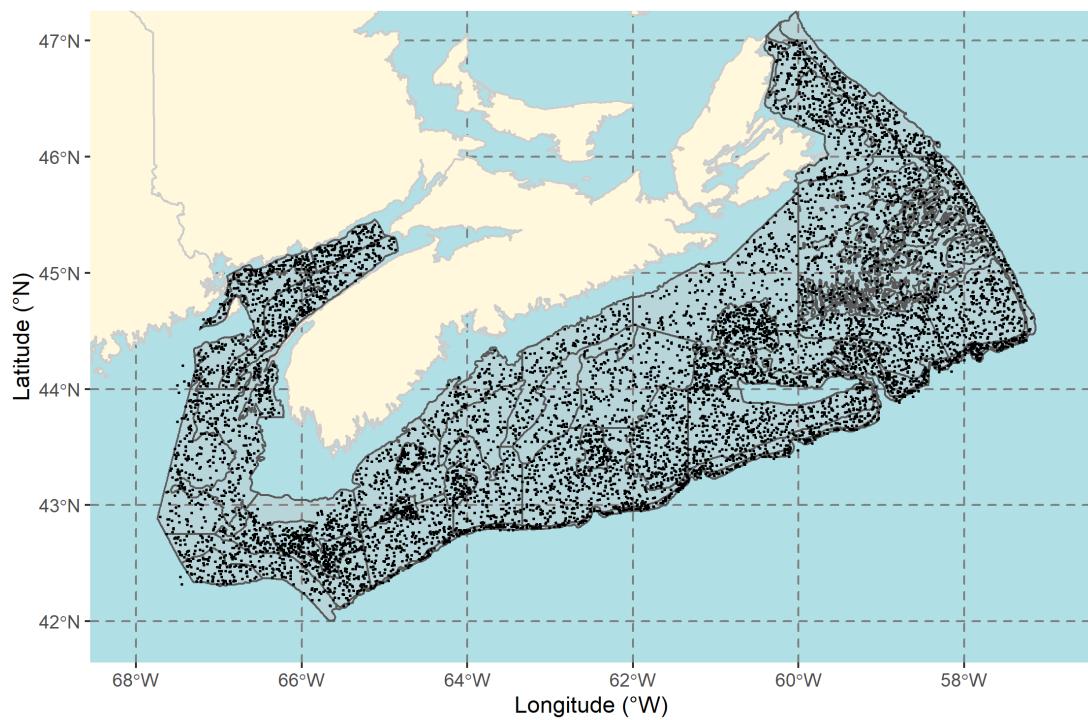


Figure 4. Map of the 9080 representative tows in the Summer survey from 1970 to 2020.

Table 4. Number of representative tows conducted in each stratum during the period 1970 to 1989.

Stratum	NAFO Div.	Area (km ²)	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
440	4VN	3173.016	4	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	5	5	6	4
441	4VN	3434.000	4	2	2	3	3	3	1	3	3	3	3	3	3	3	3	5	5	4	4	4
442	4VN	4934.658	3	2	2	2	3	3	2	3	3	3	3	3	3	3	3	3	5	6	7	5
443	4VSW	4526.012	4	2	4	4	8	3	1	2	4	4	4	3	3	5	4	4	6	6	5	2
444	4VSW	13478.450	3	2	5	4	6	4	6	7	4	4	4	5	5	6	4	4	6	6	3	6
445	4VSW	3512.982	5	2	5	4	5	5	1	3	4	4	4	5	5	3	4	5	6	4	4	4
446	4VSW	1686.094	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3
447	4VSW	5549.344	4	2	6	5	7	4	4	3	4	4	4	5	4	4	4	4	5	7	6	6
448	4VSW	4975.866	5	2	5	4	5	4	4	4	4	4	4	4	6	4	4	4	5	5	5	5
449	4VSW	494.496	2	2	2	2	3	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2
450	4VSW	1315.222	2	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
451	4VSW	504.798	1	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2
452	4VSW	1184.730	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2
453	4VSW	889.406	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2
454	4VSW	1713.566	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2
455	4VSW	7286.948	7	6	7	6	7	6	6	7	7	7	7	7	7	7	7	8	7	7	7	7
456	4VSW	3279.470	5	4	6	5	5	6	4	6	6	6	7	6	6	6	6	6	7	6	6	6
457	4VSW	2784.974	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	4	2	2
458	4VSW	2259.572	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	3	3
459	4VSW	10810.232	3	2	4	4	4	4	4	4	4	4	4	4	3	4	4	6	6	5	6	5
460	4VSW	4615.296	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	4	3	3	3
461	4VSW	3962.836	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2
462	4VSW	7266.344	3	3	4	3	4	4	4	4	4	4	4	6	4	4	4	4	6	5	4	4
463	4VSW	1037.068	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2
464	4VSW	4453.898	4	3	5	3	3	6	5	5	5	5	5	4	5	5	5	7	6	5	5	5
465	4VSW	8183.222	6	5	5	4	5	4	5	5	5	5	5	7	6	5	5	5	8	8	8	8
466	4VSW	776.084	2	2	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2
470	4X	3159.280	1	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	3	3	3
471	4X	3447.736	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
472	4X	4289.066	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4
473	4X	910.010	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
474	4X	552.874	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2
475	4X	535.704	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
476	4X	5075.452	2	2	2	2	2	2	3	2	2	2	1	2	2	2	2	2	2	4	4	4
477	4X	4230.688	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	5	4	4
478	4X	800.122	2	2	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	2	2	2
480	4X	2249.270	4	4	4	3	3	3	4	4	3	4	3	3	4	4	4	4	4	4	4	4
481	4X	6438.750	5	3	4	4	4	3	4	4	5	4	3	4	4	4	4	4	4	6	7	6
482	4X	3578.228	2	1	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	3	3	3
483	4X	1826.888	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
484	4X	7774.576	2	2	3	3	3	3	3	3	2	3	3	3	4	3	3	3	4	4	4	4
485	4X	5432.588	2	2	2	3	3	3	3	3	3	2	3	4	3	3	3	3	6	7	6	6
490	4X	2063.834	2	2	2	2	2	3	3	3	3	2	3	3	3	3	3	3	3	4	4	4
491	4X	2359.158	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
492	4X	3729.324	3	2	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
493	4X	1830.322	1	2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3
494	4X	1431.978	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
495	4X	2005.456	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2
		171809.888	134	110	146	134	153	143	135	144	141	147	145	150	150	146	143	152	171	188	177	170

Table 5. Number of representative tows conducted in each stratum during the period 1990 to 2009.

Stratum	NAFO Div.	Area (km ²)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
440	4VN	3173.016	4	4	4	3	4	4	4	4	4	4	6	4	4	4	4	4	4	4	3	4	
441	4VN	3434.000	6	5	5	5	5	5	5	5	6	7	6	6	7	6	7	6	6	5	6		
442	4VN	4934.658	5	5	6	5	6	6	6	6	7	6	6	5	6	6	7	5	5	5	6		
443	4VSW	4526.012	4	2	4	3	3	4	4	5	5	4	4	5	5	5	5	4	4	4	5	4	
444	4VSW	13478.450	7	8	8	9	6	8	8	7	8	8	9	10	9	9	9	8	10	8	6	9	
445	4VSW	3512.982	4	4	4	5	7	4	4	4	3	3	6	5	5	5	5	6	5	4	3	6	
446	4VSW	1686.094	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	
447	4VSW	5549.344	8	7	7	7	7	7	6	7	7	6	7	7	7	7	7	7	6	6	4	6	
448	4VSW	4975.866	9	6	6	7	7	7	6	7	6	7	8	8	8	8	7	8	8	6	5	7	
449	4VSW	494.496	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	
450	4VSW	1315.222	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	
451	4VSW	504.798	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	2	2	2	
452	4VSW	1184.730	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
453	4VSW	889.406	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	
454	4VSW	1713.566	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2	2	2	2	
455	4VSW	7286.948	12	10	10	9	10	10	10	13	8	11	11	11	11	11	8	12	11	7	5	8	
456	4VSW	3279.470	10	7	7	8	8	8	8	8	6	8	10	8	8	8	8	8	8	6	2	7	
457	4VSW	2784.974	4	2	2	2	2	2	2	2	1	4	2	2	2	2	2	2	2	2	2	2	
458	4VSW	2259.572	9	8	8	8	8	8	7	8	5	6	10	8	7	8	8	10	8	5	2	7	
459	4VSW	10810.232	5	5	6	4	6	6	4	5	6	6	8	6	6	6	6	6	6	5	3	6	
460	4VSW	4615.296	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	2	3	3	
461	4VSW	3962.836	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	
462	4VSW	7266.344	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	3	4	4	
463	4VSW	1037.068	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	
464	4VSW	4453.898	9	7	7	7	7	7	7	4	7	7	7	7	7	7	5	8	7	6	4	5	
465	4VSW	8183.222	12	9	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	7	8	7	
466	4VSW	776.084	3	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	1	3	2	
470	4X	3159.280	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
471	4X	3447.736	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	
472	4X	4289.066	6	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	4	3	
473	4X	910.010	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
474	4X	552.874	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
475	4X	535.704	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
476	4X	5075.452	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	
477	4X	4230.688	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
478	4X	800.122	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	3	2	2	2	
480	4X	2249.270	8	8	8	8	8	8	8	8	8	8	7	8	8	8	7	9	8	8	8	8	
481	4X	6438.750	8	9	9	9	9	7	9	9	9	9	8	9	8	9	8	9	6	12	9	7	8
482	4X	3578.228	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4	3	3	3	
483	4X	1826.888	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
484	4X	7774.576	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	4	4	3	4	
485	4X	5432.588	2	3	3	3	3	3	3	3	3	3	3	4	3	5	5	3	2	5	4	5	
490	4X	2063.834	4	4	4	4	4	5	4	4	4	3	4	4	4	4	4	4	3	3	3	4	
491	4X	2359.158	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	4	
492	4X	3729.324	3	3	3	3	3	2	3	3	3	3	3	3	3	3	5	2	3	4	4	4	
493	4X	1830.322	3	3	3	3	3	2	3	3	2	3	3	3	4	5	2	4	4	3	3	4	
494	4X	1431.978	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	4	
495	4X	2005.456	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	5	3	3	4	
		171809.888	213	189	193	190	195	195	191	193	186	191	213	201	208	216	188	222	209	177	165	196	

Table 6. Number of representative tows conducted in each stratum during the period 2010 to 2020 and for the whole 1970 to 2020 period.

Stratum	NAFO Div.	Area (km2)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
440	4VN	3173.016	4	5	4	4	4	4	4	4	0	5	4	190
441	4VN	3434.000	6	7	6	6	6	6	6	6	0	7	4	238
442	4VN	4934.658	5	6	6	6	6	6	6	6	0	6	5	240
443	4VSW	4526.012	4	6	5	5	3	7	4	5	0	9	4	214
444	4VSW	13478.450	11	13	9	8	9	9	11	10	0	6	8	352
445	4VSW	3512.982	4	7	2	4	3	4	4	4	0	6	3	215
446	4VSW	1686.094	3	4	3	3	3	2	3	2	0	3	2	145
447	4VSW	5549.344	6	8	6	7	7	7	7	7	0	6	5	291
448	4VSW	4975.866	7	10	8	8	8	7	6	6	0	7	4	299
449	4VSW	494.496	2	4	2	2	2	2	2	2	0	2	2	100
450	4VSW	1315.222	3	3	3	3	3	3	3	2	0	3	2	144
451	4VSW	504.798	2	2	2	2	2	2	2	2	0	2	2	104
452	4VSW	1184.730	2	2	2	2	1	4	3	3	0	3	3	110
453	4VSW	889.406	2	1	3	2	3	2	2	1	0	2	2	116
454	4VSW	1713.566	2	4	2	2	2	2	2	2	0	3	2	121
455	4VSW	7286.948	10	10	10	11	11	9	9	8	0	9	6	429
456	4VSW	3279.470	7	9	8	8	6	5	6	6	0	6	4	331
457	4VSW	2784.974	2	4	2	2	2	3	3	3	0	3	2	113
458	4VSW	2259.572	6	9	8	6	4	5	5	5	0	6	3	269
459	4VSW	10810.232	6	7	6	6	6	7	7	6	0	9	7	262
460	4VSW	4615.296	3	4	4	3	3	5	5	5	3	6	5	151
461	4VSW	3962.836	2	3	3	2	2	3	3	3	2	3	3	113
462	4VSW	7266.344	4	6	4	4	5	5	5	5	0	5	5	212
463	4VSW	1037.068	2	3	2	2	2	3	2	2	0	2	2	107
464	4VSW	4453.898	6	7	7	7	7	6	6	4	0	6	4	288
465	4VSW	8183.222	8	10	10	10	10	10	9	7	3	10	7	397
466	4VSW	776.084	2	2	2	2	2	2	2	3	0	3	2	118
470	4X	3159.280	2	2	3	2	2	3	3	3	4	3	2	112
471	4X	3447.736	2	2	3	2	2	3	3	3	4	4	3	110
472	4X	4289.066	4	6	4	4	4	4	4	4	4	4	4	172
473	4X	910.010	2	2	2	2	2	2	2	2	2	2	2	104
474	4X	552.874	2	2	2	2	2	2	2	2	2	2	2	100
475	4X	535.704	2	2	2	2	2	2	2	2	2	2	2	103
476	4X	5075.452	4	4	4	4	4	5	5	5	5	5	5	177
477	4X	4230.688	5	4	5	5	6	5	5	4	4	6	4	204
478	4X	800.122	2	2	2	2	2	2	2	3	2	2	2	119
480	4X	2249.270	8	7	8	8	6	7	7	7	5	7	5	306
481	4X	6438.750	8	10	9	9	9	8	10	9	6	9	6	350
482	4X	3578.228	3	4	3	3	3	3	4	4	3	4	3	141
483	4X	1826.888	2	3	2	2	2	2	3	3	2	3	2	105
484	4X	7774.576	3	5	5	5	4	6	5	7	7	7	7	186
485	4X	5432.588	5	6	5	5	5	6	6	6	4	6	5	196
490	4X	2063.834	3	4	2	4	3	4	4	4	3	4	3	173
491	4X	2359.158	4	4	4	4	4	4	4	4	3	4	3	168
492	4X	3729.324	4	6	4	4	4	3	4	4	3	4	4	171
493	4X	1830.322	3	4	4	4	3	3	4	6	3	3	3	159
494	4X	1431.978	4	4	4	4	3	4	4	3	2	4	3	128
495	4X	2005.456	3	4	4	4	2	4	4	4	3	4	3	127
		171809.888	196	243	210	208	196	212	214	208	81	227	175	9080

420 **3.2 Distribution of depth, bottom temperature and bottom salinity from survey tows**

421 The depth, bottom temperature and bottom salinity cumulative frequency distribution for the
422 survey are presented in Figure 5.

423 **4 Discussion**

424 This report builds on previous work and former atlases by updating a comprehensive suite of
425 indices to give a snapshot of population status and environmental preferences of 104 fish and
426 invertebrate species. The current document is not meant to replace stock assessments, species-
427 specific analyses of abundance, biomass and distribution, or any targeted attempts to integrate
428 information about species or group of species from the wide and disparate sources of data about
429 marine organisms in the area covered by the DFO Maritimes summer trawl survey. It is rather
430 meant to provide a reproducible set of tools to extract and visualize the information collected
431 in the summer groundfish research vessel survey. It is hoped that this document can provide a
432 stepping stone to conduct other ecological analyses using the trawl survey data and increase
433 reproducibility and transparency of ecological information collected annually.

434 **4.1 Diversity of approaches used for mapping fish and invertebrates in the Scotian Shelf
435 bioregion**

436 Different methods have been applied in the Northwest Atlantic, and specifically on the Scotian
437 Shelf bioregion, to map fish and invertebrate species distribution. The present report, for
438 example, builds upon the atlas of important habitat developed to map the persistence of relatively
439 high biomass for key fish species using the summer groundfish research vessel survey (Horsman
440 and Shackell 2009). Important habitat was obtained by interpolating observed weight per each
441 species using an inverse-distance weighted (IDW) methodology, and calculating areas with
442 relatively persistent high biomass for periods representing different fishery management eras.
443 To compliment information from this atlas, including additional representations of biomass and
444 diversity, a similar IDW interpolation mapping procedure was followed by Smith et al. (2015),
445 Ward-Paige and Bundy (2015), and Bundy et al. (2017). The summer groundfish research vessel
446 survey is typically conducted during the month of July. However, from the fall of 1978 through to
447 the spring of 1985, DFO also conducted spring and fall surveys using the same sampling design.
448 This unique seasonal data was used to map the seasonal spatial distribution of key demersal
449 and other fish species using IDW interpolation on the Scotian Shelf from the spring, summer
450 and fall between 1978 and 1985 (Smith et al. 2015). Following recommendations provided by
451 Kenchington and Kenchington (2017), the spatial distribution of three indicators of biodiversity
452 for fish and invertebrates were mapped using IDW interpolation to identify areas with persistently
453 high values across fishery management eras, and compared with areas of persistently high
454 abundance for selected species (Ward-Paige and Bundy 2015). This analysis revealed a lack of
455 consistent relationships between areas of persistent high diversity and persistent high biomass,
456 suggesting that both can be used as independent and important spatial indicators of the system
457 (Ward-Paige and Bundy 2015). Groupings of fishes and invertebrates based on size, habitat
458 and feeding guild, were also mapped using IDW interpolations to identify hotspots of functional

459 group diversity (Bundy et al. 2017). This analysis revealed a spatially and temporally variable
460 distribution of functional diversity across the Scotian Shelf with notable areas of high and low
461 diversity (Bundy et al. 2017). Top quintiles of each functional group using the IDW approach
462 were used as representative layers for fish and invertebrates in the MPA Network design in the
463 Scotian Shelf Bioregion (Serdynska et al. In press). IDW interpolation methods have also been
464 used to map the distribution of individual species such as sea cucumbers (*Cucumaria frondosa*)
465 in the Scotian Shelf bioregion (Shackell et al. 2013), and sea scallop (*Placopecten magellanicus*)
466 in Georges and Browns Bank (Hubley et al. 2014).

467 Species Distribution Modelling (SDM), instead of IDW, can also be used to evaluate spatio-
468 temporal dynamics by predicting and understanding past, present and future distribution
469 of species using environmental predictors (Robinson et al. 2017). A variety of modelling
470 approaches are being implemented in Maritimes Region to map and predict fish and invertebrate
471 species distribution by incorporating environmental predictors to account for seasonal and
472 temporal variability. For example, a stock assessment of snow crab (*Chionoecetes opilio*) on
473 the Scotian Shelf used data from the snow crab survey from 2005 to 2018 to map spatial data
474 products for this stock, including annual predicted interpolations of potential habitat using
475 Generalized Additive Models (GAM) and several environmental covariates including depth,
476 curvature, slope, species composition, and annual temperature (Zisserson et al. 2019). Sea
477 scallop predicted habitat using Maximum Entropy (MaxEnt) models were computed for German
478 Bank using data compiled via benthic habitat mapping and seafloor geotechnical surveys in
479 2006, 2009, and 2010 (Brown et al. 2012). Predictions in the Scotian Shelf bioregion and the
480 Northeast United States using datasets from DFO and the National Oceanic and Atmospheric
481 Administration from 1993 to 2012 also predicted sea scallop habitat at a wider scale based
482 on three scenarios of seasonal temperature and salinity climatologies (NOAA) (Lowen et
483 al. 2019). Offshore American lobster stock assessments (*Homarus americanus*) used data
484 from the RV, DFO Georges Bank, and National Marine Fisheries Service (NMFS) Northeast
485 Fisheries Science Center (NEFSC) bottom trawl surveys (1970 to 2015) to predict species
486 distribution using boosted regression trees and several environmental predictors (bathymetry,
487 slope, curvature, and annual temperature interpolations) (Cook et al. 2017). Information on
488 the potential for recovery of cusk (*Brosme brosme*) used data from the bottom longline Halibut
489 industry survey and Cusk absences in the Summer groundfish research vessel survey from
490 1998-2013 to predict suitable habitat using GAM, MaxEnt, and random forest models and
491 several physical environmental variables (e.g. complexity, benthic current stress and complexity,
492 temperature, salinity, primary production, chlorophyll, suspended matter) (Harris et al. 2018).
493 Atlantic halibut (*Hippoglossus hippoglossus*) assessments using Summer groundfish research
494 vessel survey and NOAA survey data from 2001 to 2013 predicted juvenile habitat using MaxEnt
495 model and environmental predictors (bathymetry, slope, bottom temperature) (French et al.
496 2018). Persistent areas of high Atlantic halibut juvenile abundance were predicted using data
497 from 27 bottom trawl surveys combined (NMFS and DFO) from 1978 to 2013 and applying
498 Bayesian hierarchical spatiotemporal models with two environmental predictors (depth and
499 temperature) (Boudreau et al. 2017).

500 These examples of mapping efforts in Maritimes Region showcase the diversity of approaches
501 relevant to a variety of important research questions and management applications. Approaches,
502 methods, datasets, and environmental predictors are selected based on individual project
503 research questions, and considerations for each species, communities or stock. This allows
504 research groups to maintain innovation and keep up with emerging methods and technologies to

505 improve assessments, predictions, and ultimately, science advice. The diversity of approaches
506 also leads to complexity when looking across studies as each data compilation and predictive
507 method carries its own independent assumptions and can lead to different spatial outputs.

508 **4.2 Interpreting spatial results for marine spatial planning purposes**

509 Fisheries and Oceans Canada is leading a marine spatial planning process that brings together
510 relevant authorities and stakeholders to better coordinate how we use and manage marine
511 spaces to achieve ecological, economic and social objectives. Operationalizing marine spatial
512 planning includes a series of steps, including the process of analyzing existing conditions
513 by collecting and mapping information about ecological, environmental and oceanographic
514 conditions (Ehler and Douvere 2009; Agardy et al. 2011). Mapping the distribution of species
515 is critical for the implementation of spatial management and as a first step in marine spatial
516 planning processes. Species distribution have supported the identification of important sites for
517 a given species or areas of high richness and diversity, which in turn can be used to inform siting
518 decisions of new activities such as Marine Protected Areas (MPA), aquaculture sites or wind
519 turbines. In the Scotian Shelf bioregion, mapping species distributions has been used to highlight
520 areas of high biological diversity to support the identification of Ecologically or Biologically
521 Significant Areas (Ricard and Shackell 2013; Ward-Paige and Bundy 2015), to distinguish
522 important and persistent habitat of significant species and functional groups to support MPA and
523 conservation planning (Horsman and Shackell 2009; Smith et al. 2015; Ward-Paige and Bundy
524 2015; Bundy et al. 2017), to identify important habitat for Species at Risk (Harris et al. 2018) and
525 to highlight reserves for data-poor invertebrate fisheries (Shackell et al. 2013). Mapping species
526 distribution has also been used to illustrate multi-decadal scale projections of changes in species
527 distribution in the context of climate change and adaption (Stanley et al. 2018; Greenan et al.
528 2019).

529 In support of the marine spatial planning process, a public web-based atlas with relevant
530 geospatial information is being developed to support decision-making. This Atlantic Canada-
531 wide compilation of data and information will be a web-based, public platform with interactive
532 maps of ocean ecosystems, human uses and management areas. This atlas cannot host the
533 vast diversity of products and mapping approaches available in Maritimes Region. Consequently,
534 we recommend that data products presented in this report should not be used for the atlas until
535 an evaluation of the spatial information available and used in the past, is conducted.

536 This diverse portfolio of approaches and applications is not unique to the Maritimes Region. A
537 recent review of global distribution modelling efforts recommended the adoption of a consistent
538 framework that integrates multi-model approaches and a clear expression of errors and
539 uncertainties (Robinson et al. 2017). In this context, Pacific Region has developed two initiatives
540 to enable consistency and frequent publication, reproducibility, and transparency. One initiative
541 developed a reproducible report to give a synthesis of data availability, population trends, fishing
542 trends, growth and maturity patterns for 113 groundfish species in British Columbia to support
543 stock assessment (Anderson et al. 2019). The second initiative developed a SDM framework
544 that was applied to twelve species on Canada's Pacific coast as part of the Regional Response
545 Plan (Nephin et al. 2019). The Maritimes and Gulf region, through this and past reports, are also
546 using similar reproducible approaches to facilitate annual updates and transparency (Ricard and

547 Shackell 2013; Ricard et al. 2021).

548 Recognizing the diversity of approaches for mapping fish and invertebrates in the Scotian Shelf
549 bioregion, we recommend the development of a regional community of practice to compare
550 and evaluate approaches for mapping, interpolating and/or modelling fish and invertebrates
551 so future publications and advice related to spatial outputs can lead to more comparable work
552 and consistent science advice to support processes such as marine spatial planning. At the
553 international level, guidelines and standards related to appropriate variables and methods
554 for mapping and modeling species and communities of deep-sea habitats were proposed to
555 encourage the production of publications that will lead to more comparable work (Kenchington
556 et al. 2019). Similar general guidance for how groups approach mapping activities would be a
557 worthwhile product in Maritimes Region. Until then, we propose the use of the Open Data record
558 for the Maritimes RV surveys (DFO 2021) as a precursor to the public web-based marine spatial
559 planning atlas.

560 **5 Acknowledgements**

561 We thank all the dedicated personnel involved in running trawl surveys in the Maritimes Region
562 and the numerous colleagues in Maritimes Region that have shared information and advice in
563 support of this report. The assistance of the Gulf Region secondary publications coordinators,
564 Alicia Cassidy and Jeff Clements, in getting this report published is well appreciated. This
565 document greatly benefited from the constructive comments from two reviewers.

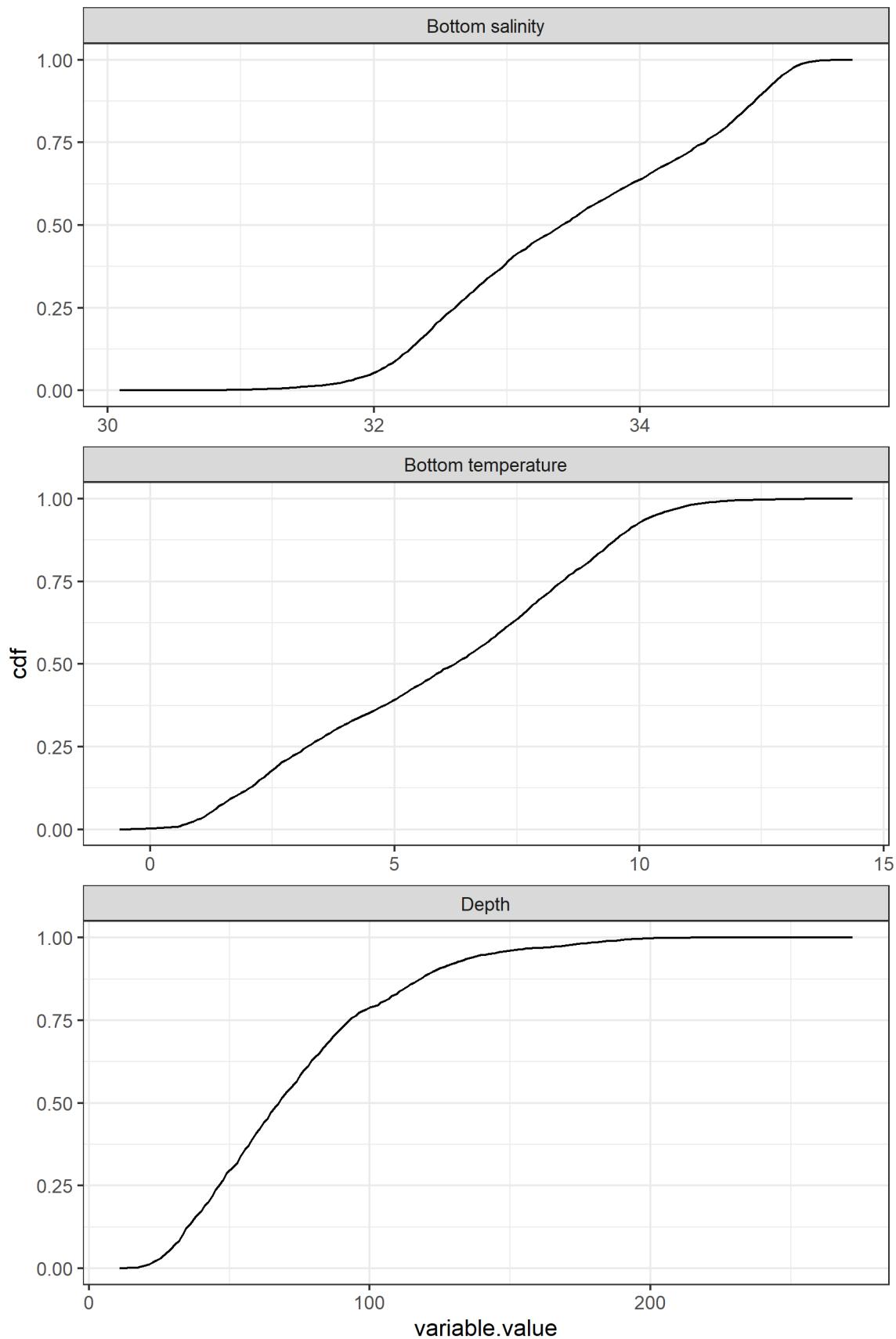


Figure 5. Cumulative frequency distribution of depth, bottom temperature and bottom salinity of representative sets from the summer survey. 27

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7 Appendix

719

7.1 Atlantic cod (*Morue franche*) - species code 10 (category LF)

720

Scientific name: [Gadus morhua](#)

721

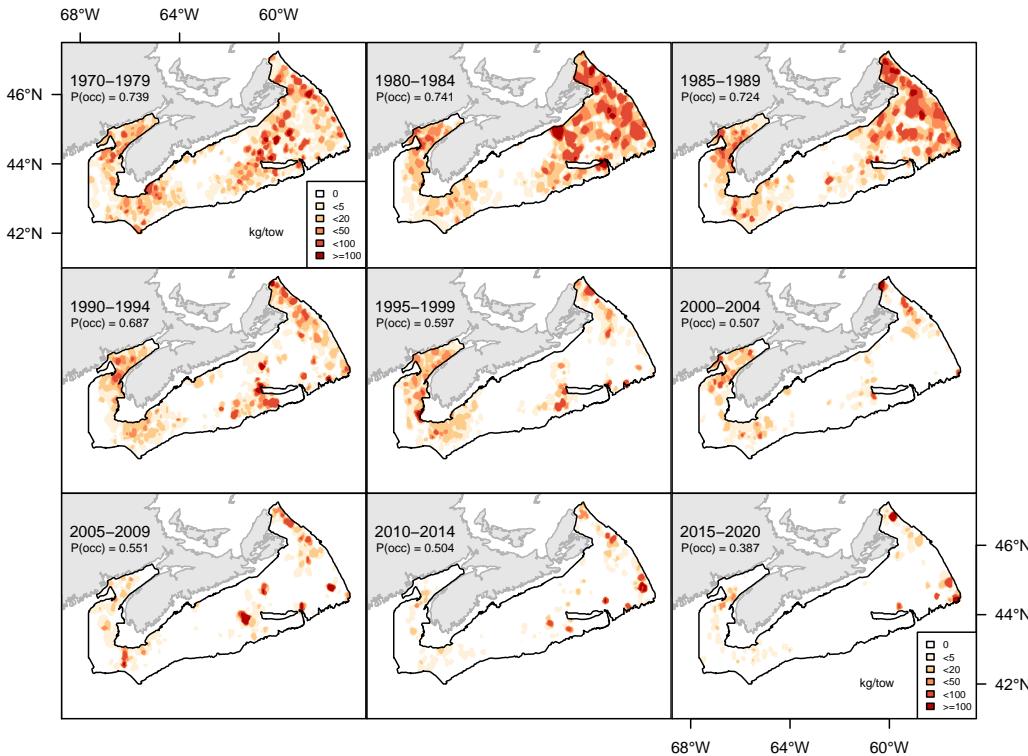


Figure 7.1A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic cod.

722

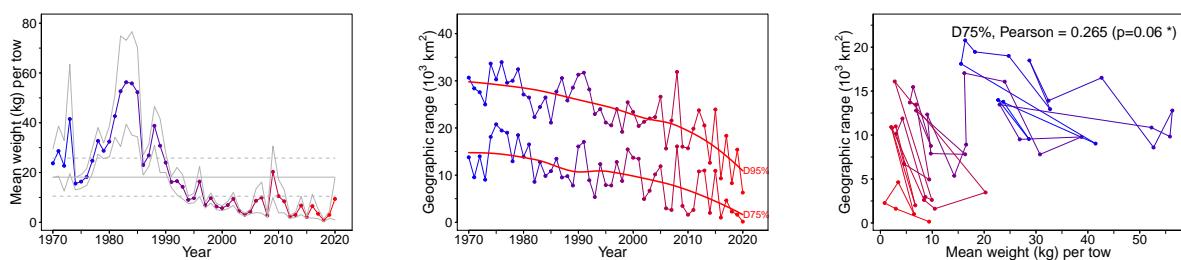


Figure 7.1B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic cod.

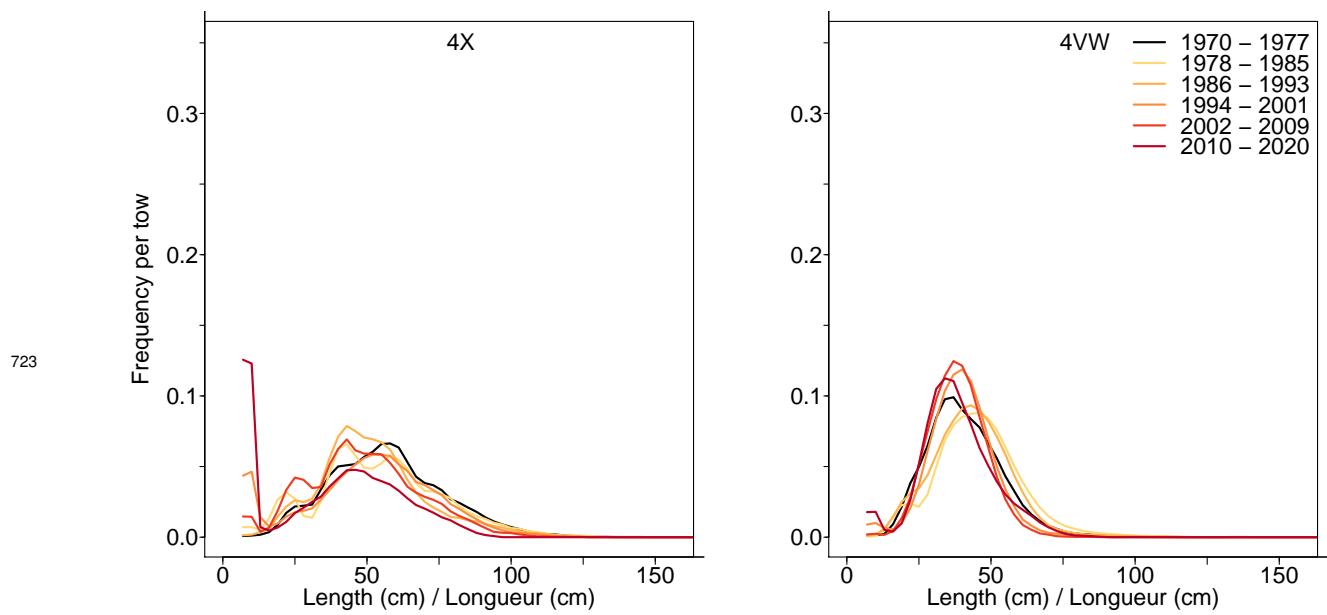


Figure 7.1C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic cod.

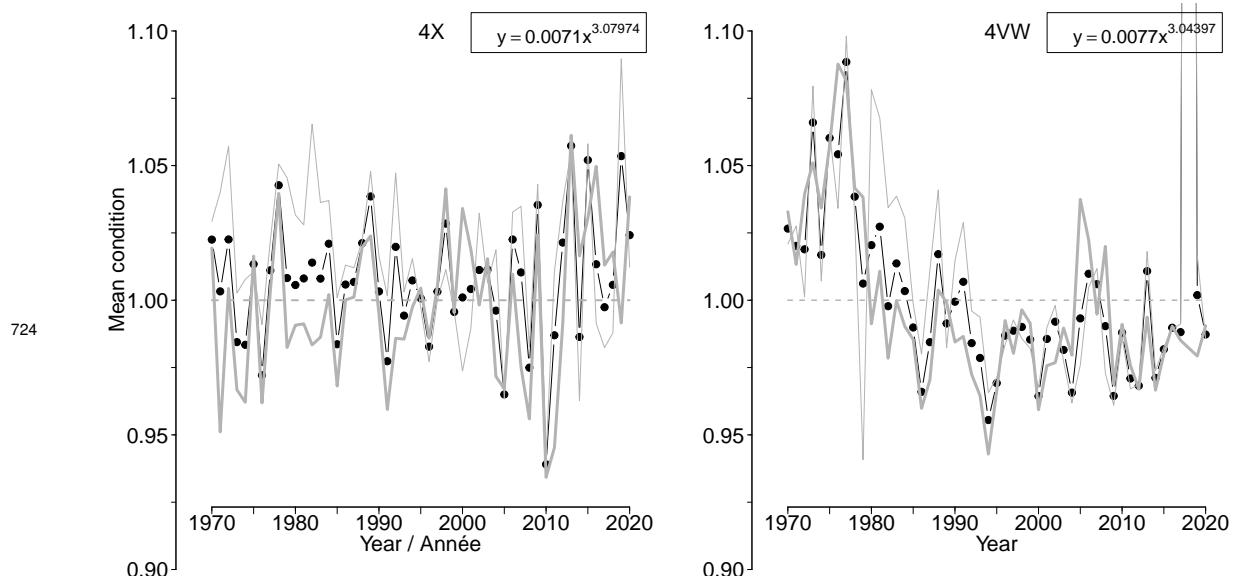
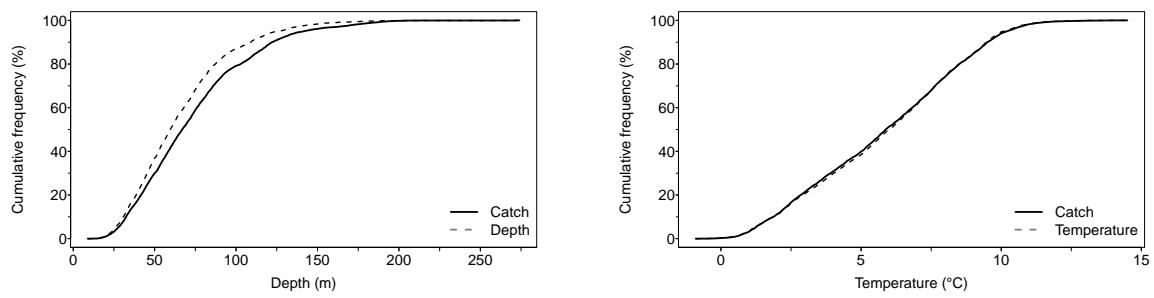
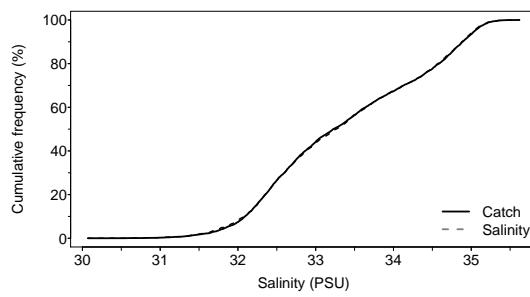


Figure 7.1D. Average fish condition in NAFO units 4X and 4VW for Atlantic cod.



725



Freq	Depth	Temp	Sal
F5	26	1.2	31.00
F25	43	3.5	32.47
F50	60	6.0	33.27
F75	82	8.1	34.40
F95	126	10.0	35.03

Figure 7.1E. Catch distribution by depth, temperature and salinity of Atlantic cod.

726

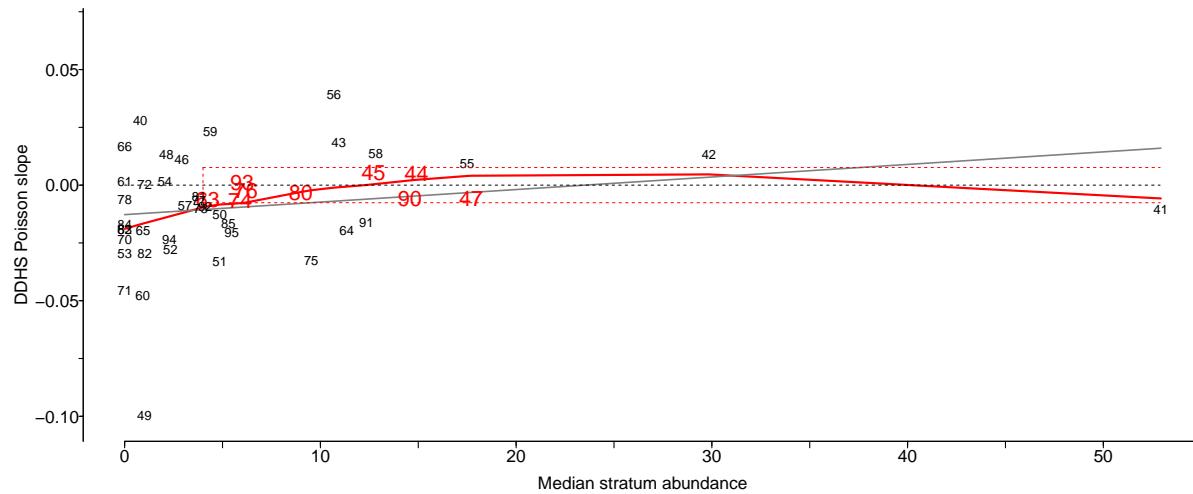


Figure 7.1F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic cod.

727

7.2 Haddock (Aiglefin) - species code 11 (category LF)

728

Scientific name: [Melanogrammus aeglefinus](#)

729

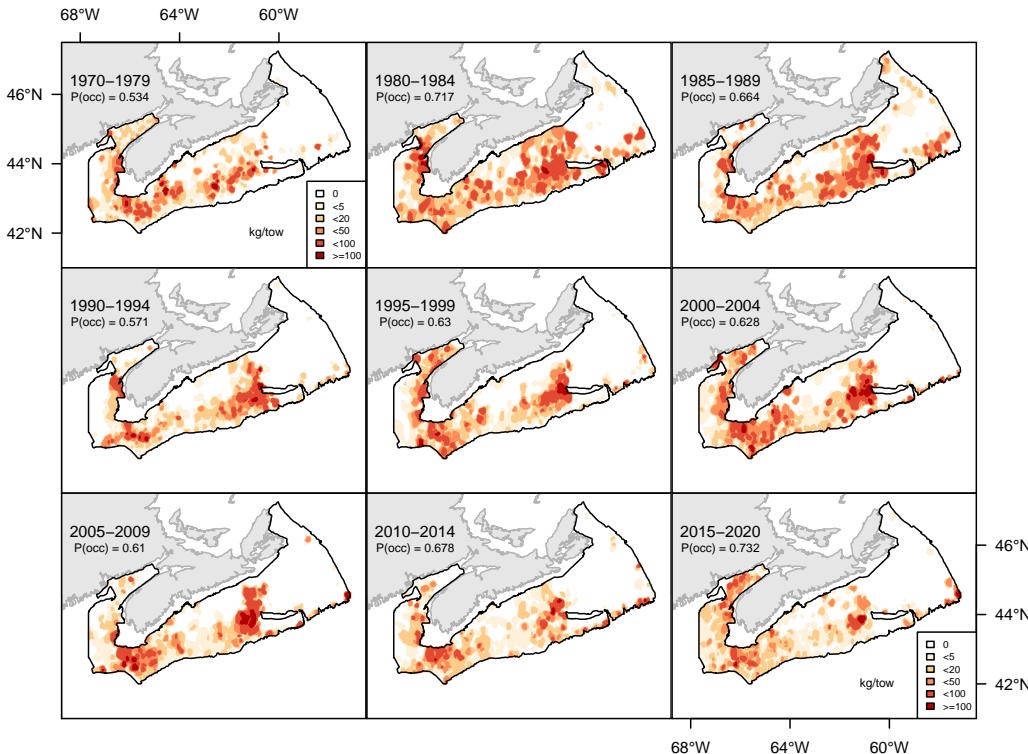


Figure 7.2A. Inverse distance weighted distribution of catch biomass (kg/tow) for Haddock.

730

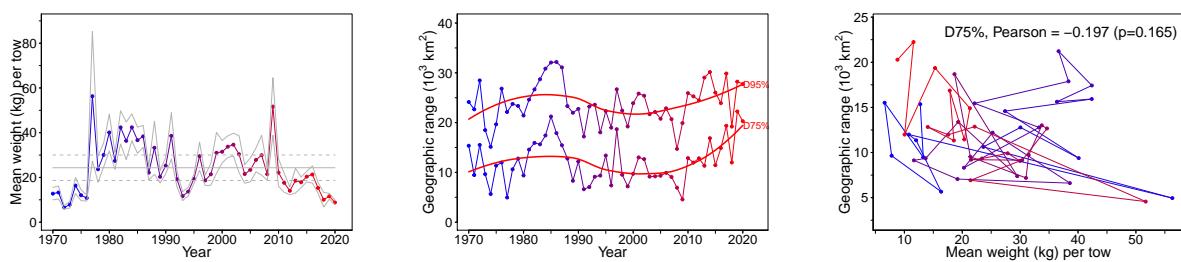


Figure 7.2B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Haddock.

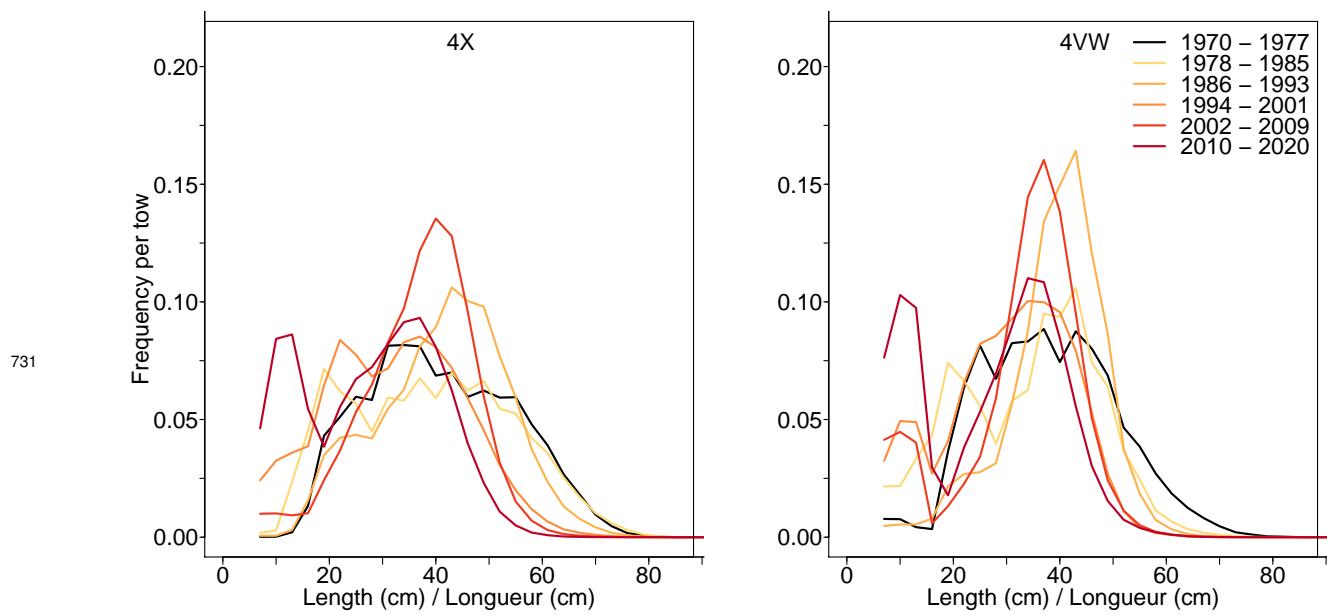


Figure 7.2C. Length frequency distribution in NAFO units 4X and 4VW for Haddock.

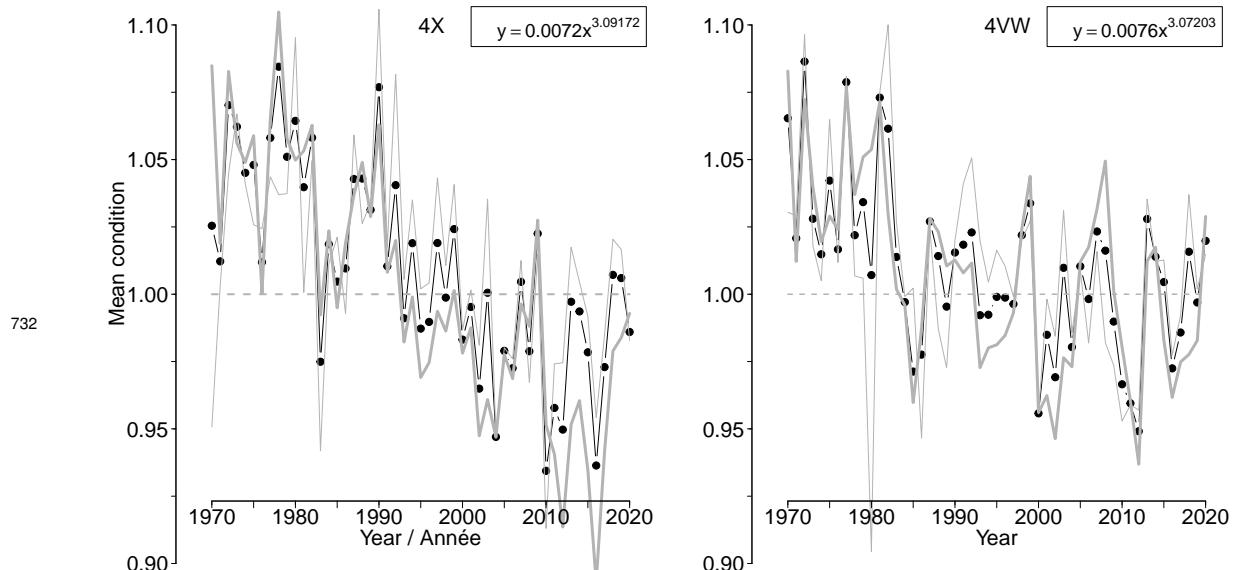
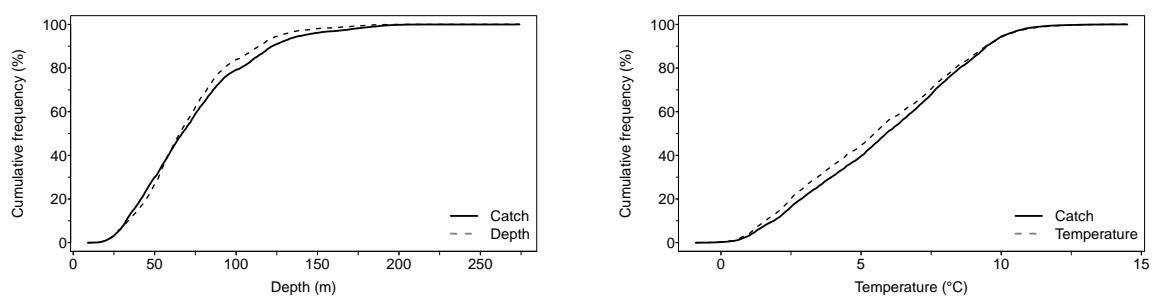
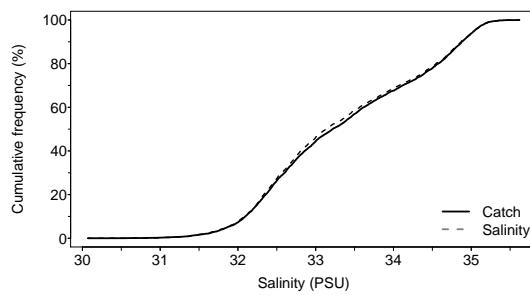


Figure 7.2D. Average fish condition in NAFO units 4X and 4VW for Haddock.



733



Freq	Depth	Temp	Sal
F5	27	1.1	31.00
F25	49	3.0	32.45
F50	66	5.5	33.14
F75	87	7.9	34.36
F95	127	10.0	35.03

Figure 7.2E. Catch distribution by depth, temperature and salinity of Haddock.

734

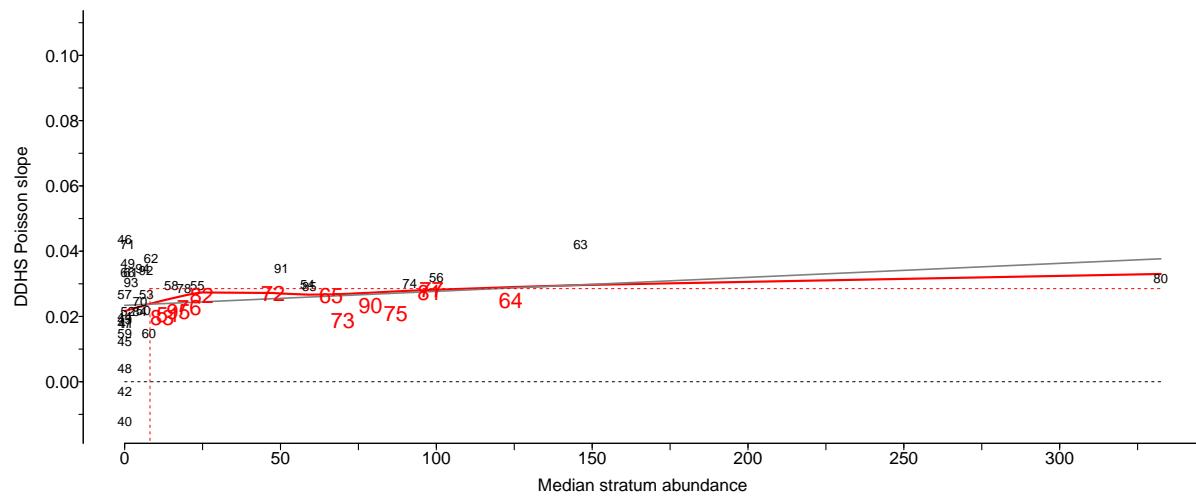


Figure 7.2F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Haddock.

735

7.3 White hake (Merluche blanche) - species code 12 (category LF)

736

Scientific name: [Urophycis tenuis](#)

737

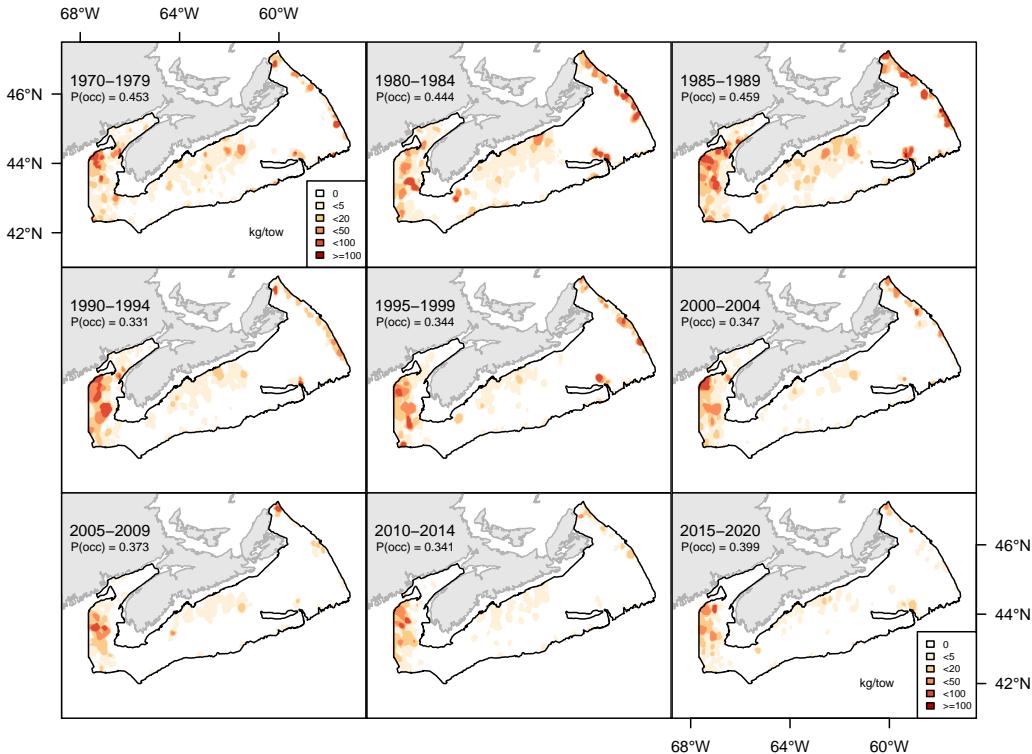


Figure 7.3A. Inverse distance weighted distribution of catch biomass (kg/tow) for White hake.

738

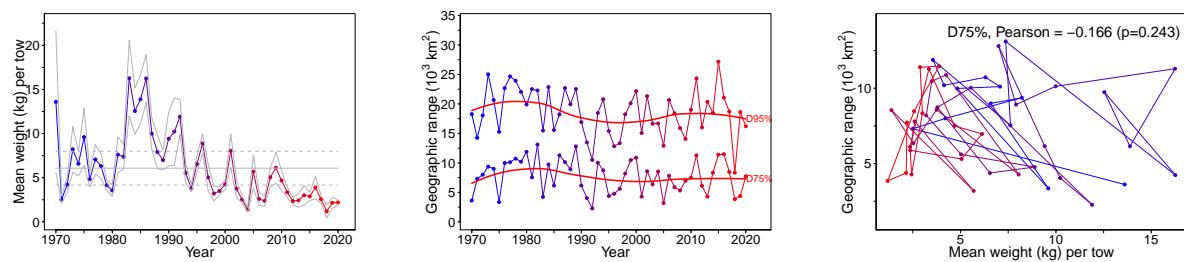


Figure 7.3B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of White hake.

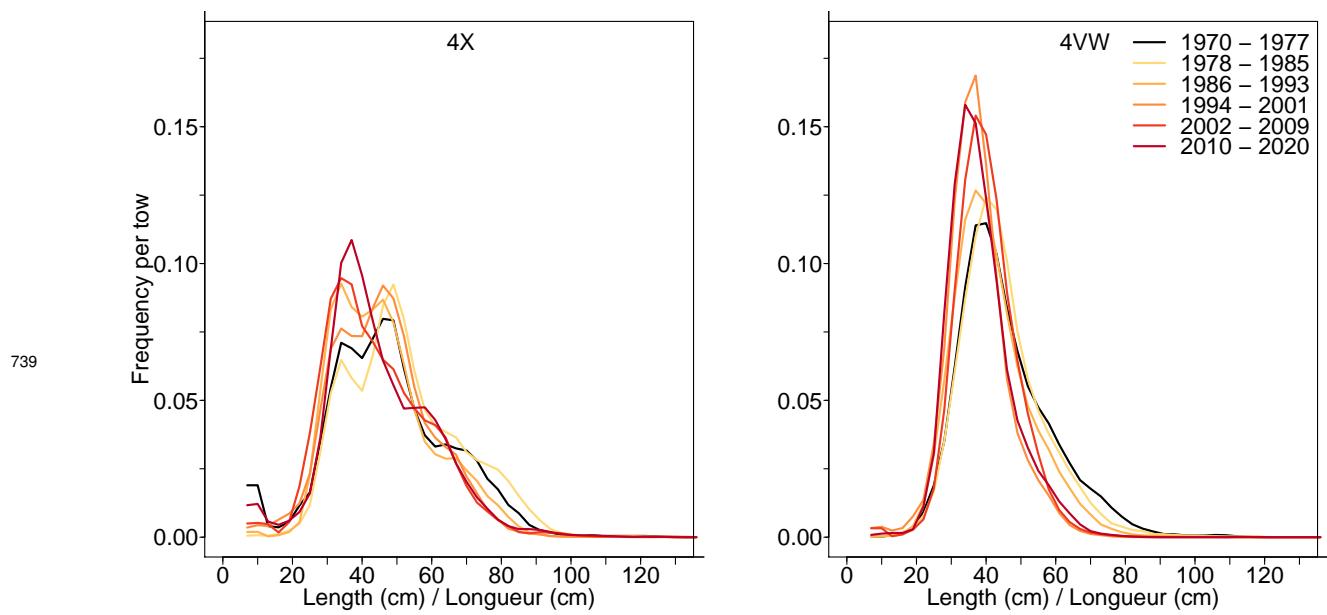


Figure 7.3C. Length frequency distribution in NAFO units 4X and 4VW for White hake.

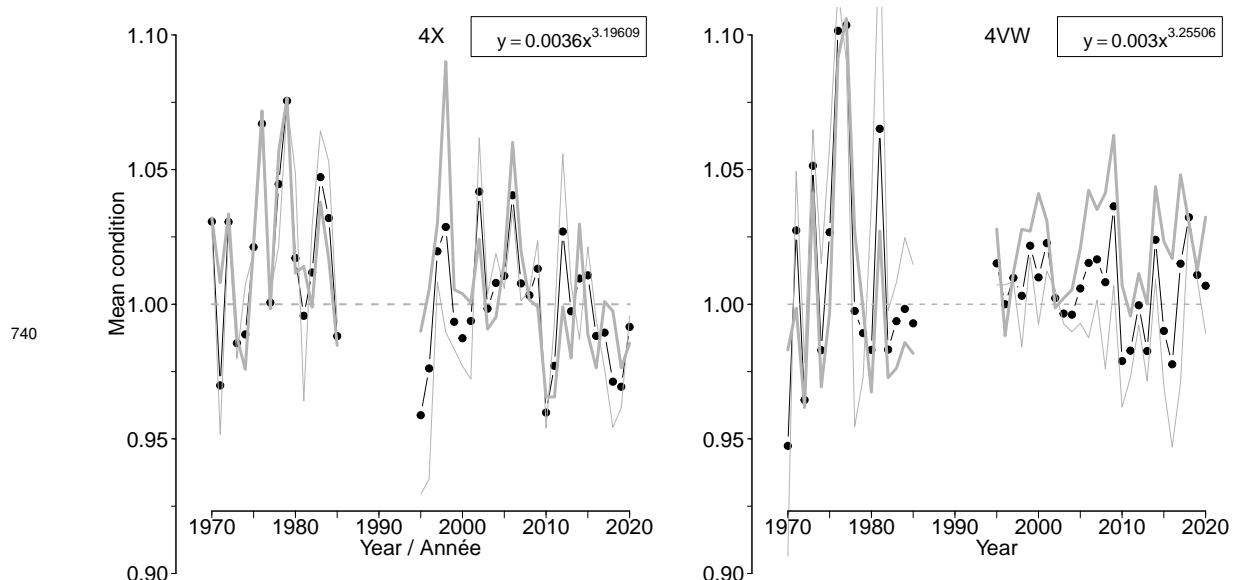
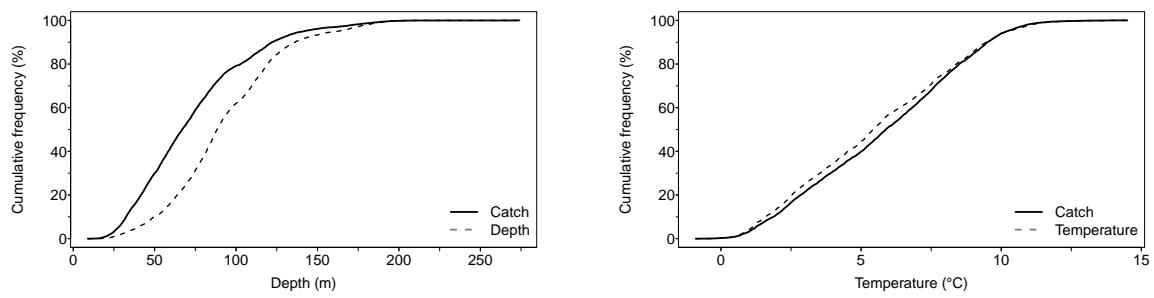
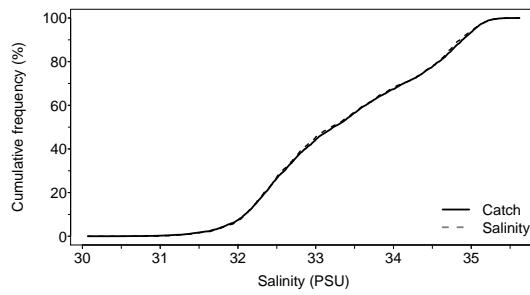


Figure 7.3D. Average fish condition in NAFO units 4X and 4VW for White hake.



741



Freq	Depth	Temp	Sal
F5	40	1.1	31.00
F25	70	3.0	32.46
F50	89	5.5	33.20
F75	115	7.9	34.39
F95	163	10.0	35.04

Figure 7.3E. Catch distribution by depth, temperature and salinity of White hake.

742

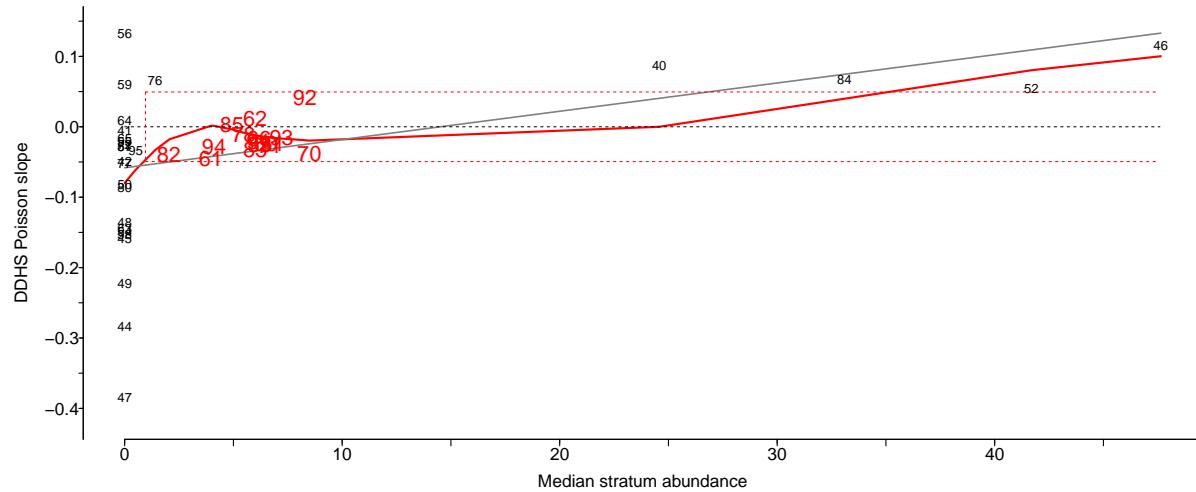


Figure 7.3F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for White hake.

743

7.4 Red hake (Merluche écureuil) - species code 13 (category LF)

744

Scientific name: [Urophycis chuss](#)

745

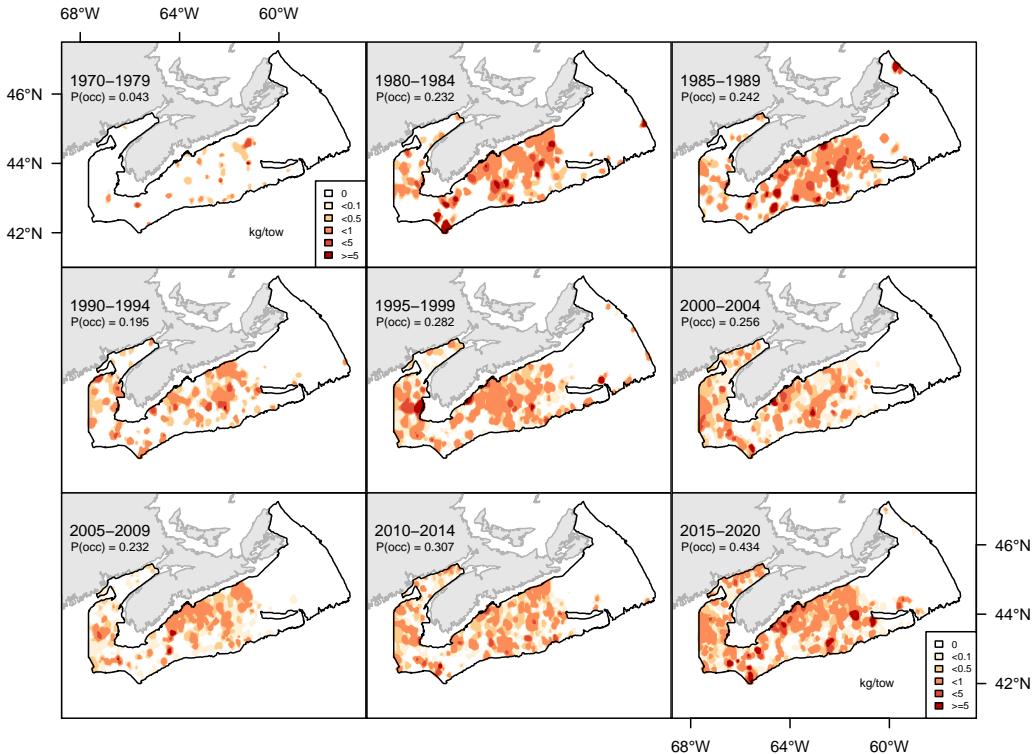


Figure 7.4A. Inverse distance weighted distribution of catch biomass (kg/tow) for Red hake.

746

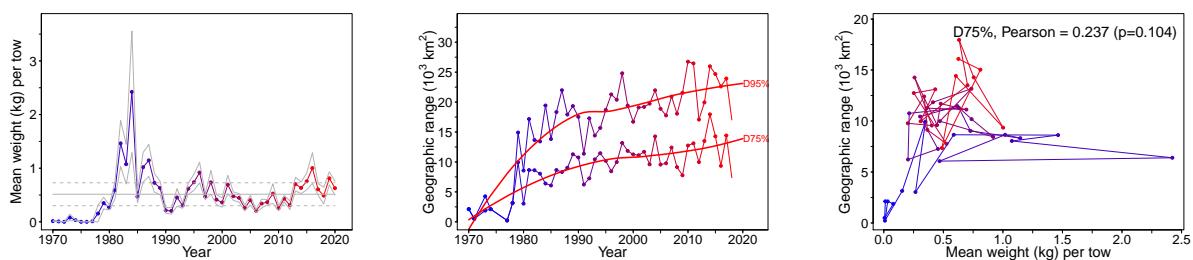


Figure 7.4B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Red hake.

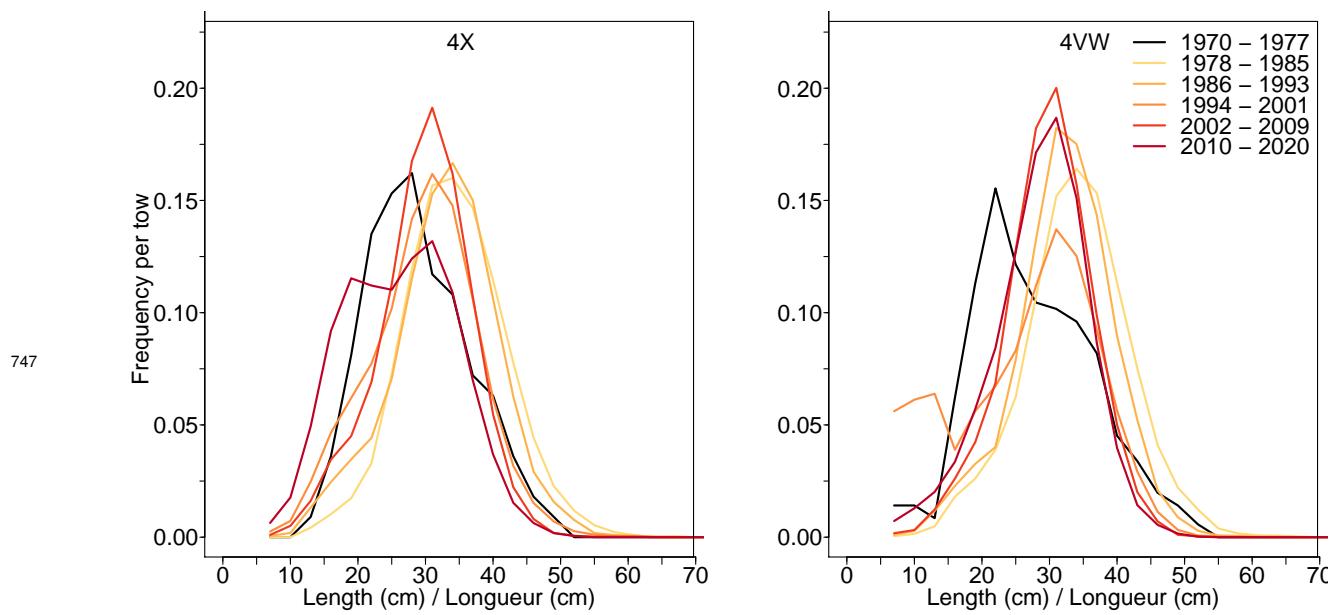


Figure 7.4C. Length frequency distribution in NAFO units 4X and 4VW for Red hake.

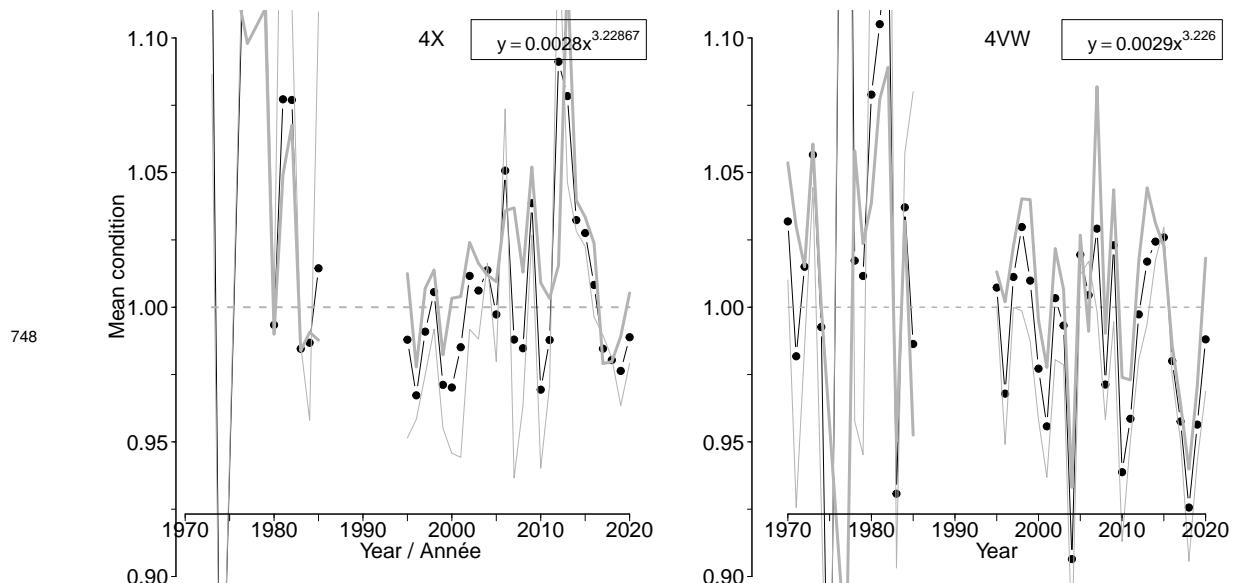
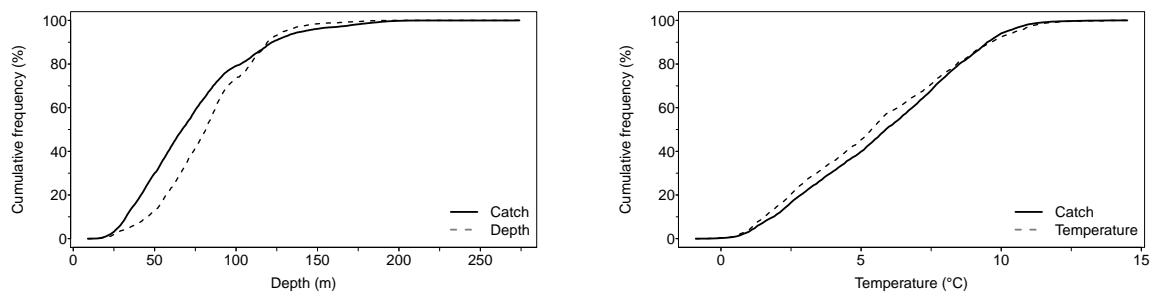
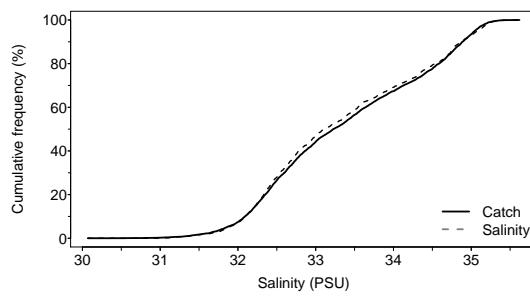


Figure 7.4D. Average fish condition in NAFO units 4X and 4VW for Red hake.



749



Freq	Depth	Temp	Sal
F5	35	1.1	31.00
F25	62	2.9	32.43
F50	82	5.4	33.12
F75	103	7.9	34.32
F95	130	10.0	35.08

Figure 7.4E. Catch distribution by depth, temperature and salinity of Red hake.

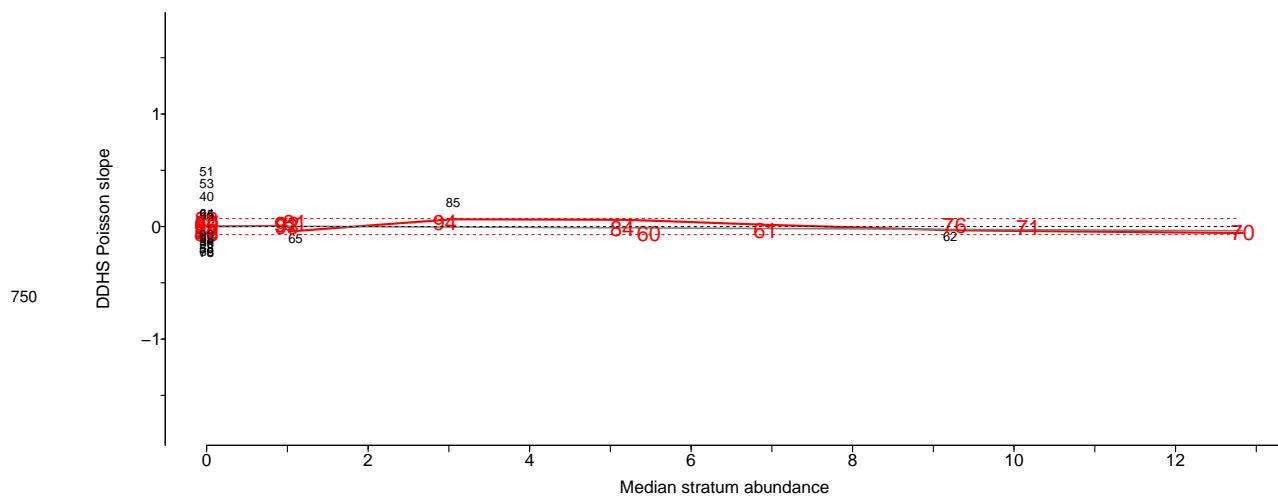


Figure 7.4F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Red hake.

751

7.5 Silver hake (*Merlu argenté*) - species code 14 (category LF)

752

Scientific name: [Merluccius bilinearis](#)

753

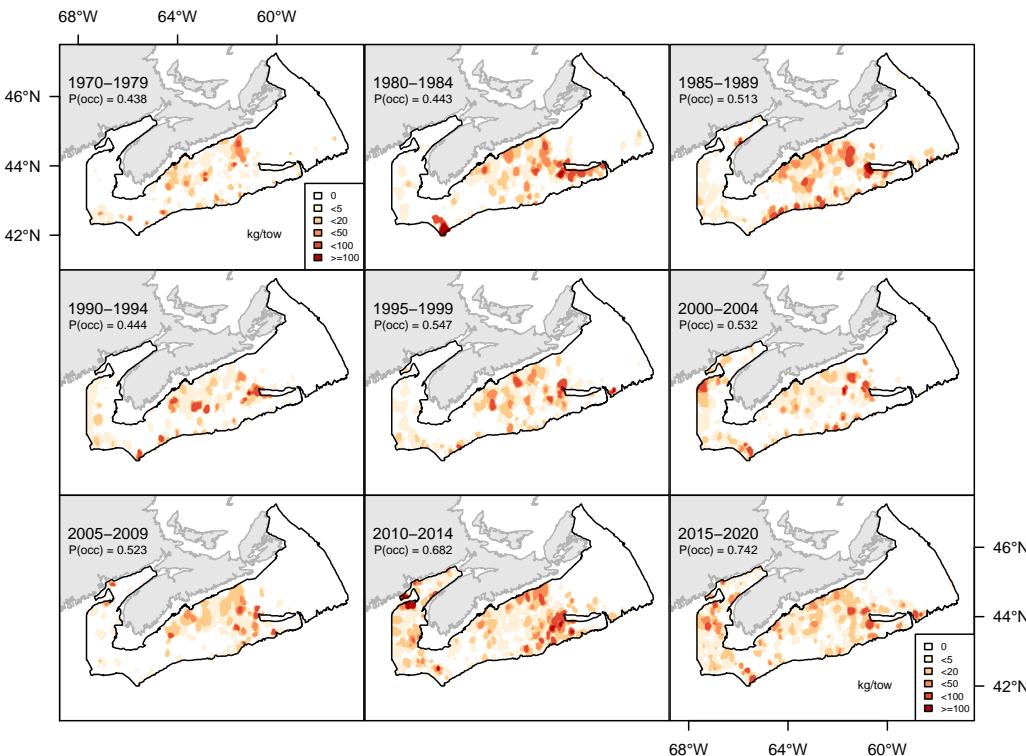


Figure 7.5A. Inverse distance weighted distribution of catch biomass (kg/tow) for Silver hake.

754

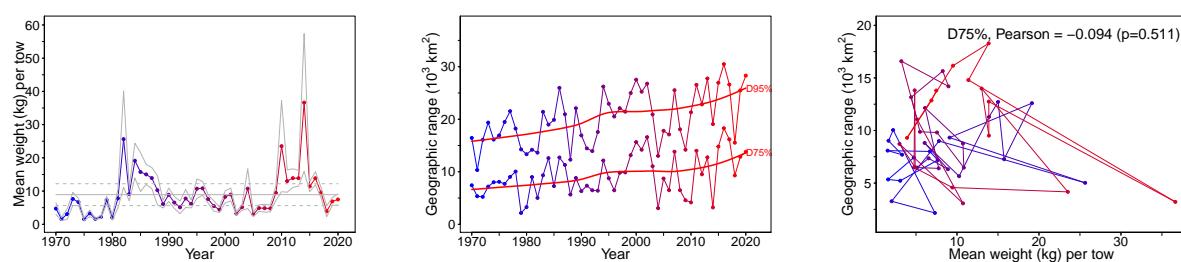


Figure 7.5B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Silver hake.

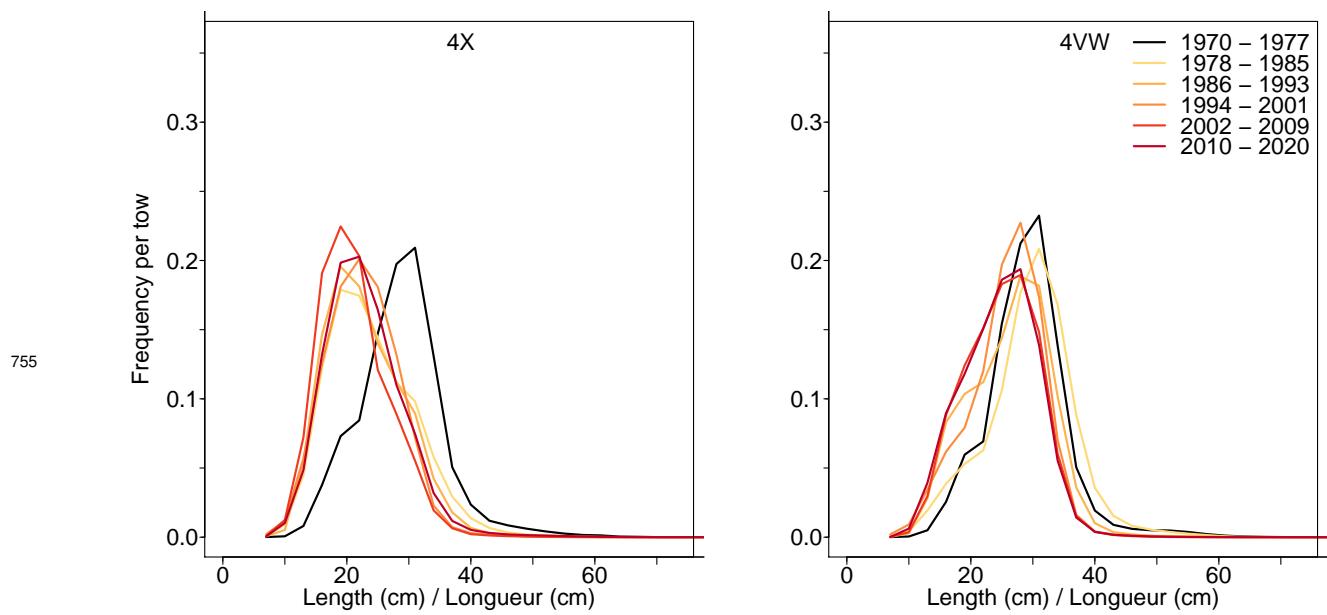


Figure 7.5C. Length frequency distribution in NAFO units 4X and 4VW for Silver hake.

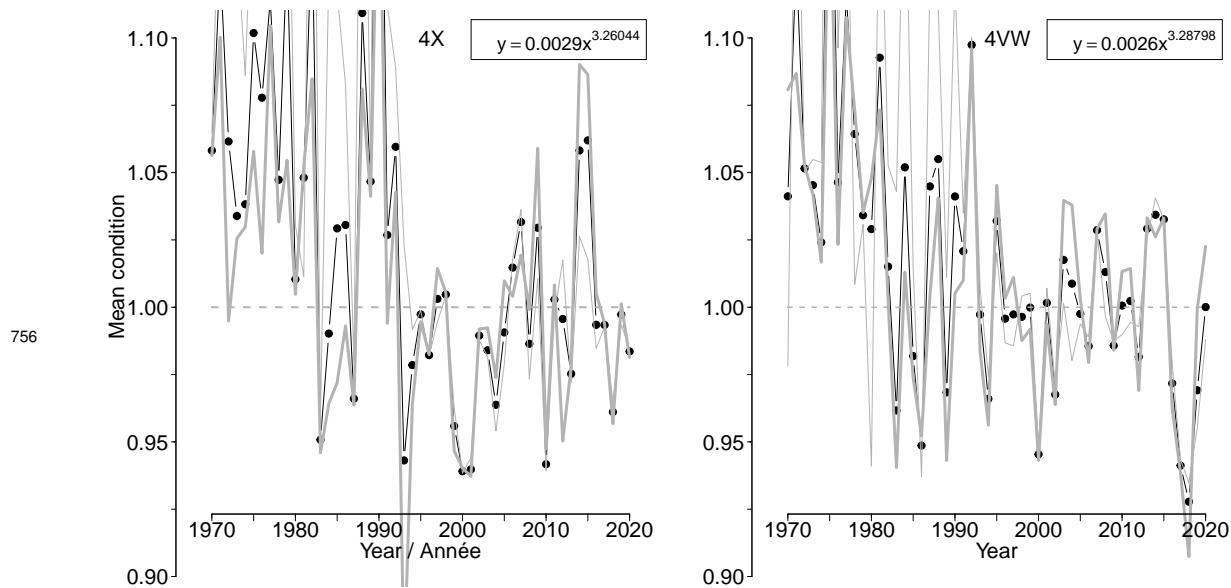
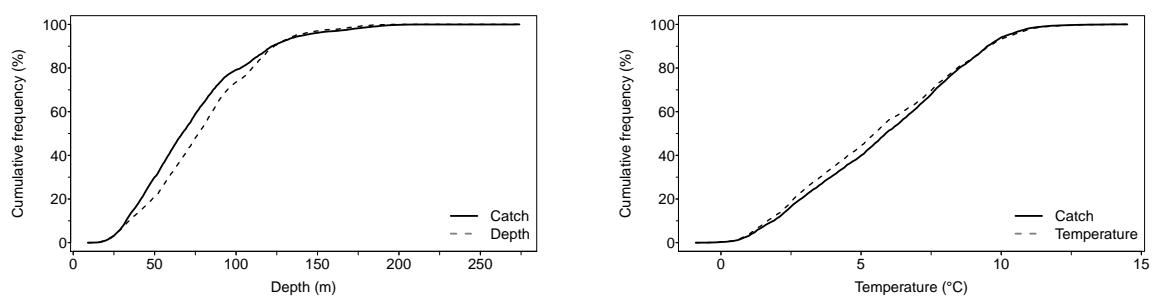
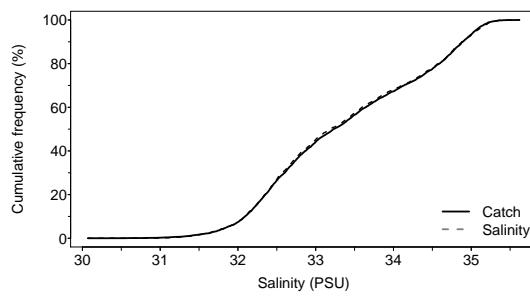


Figure 7.5D. Average fish condition in NAFO units 4X and 4VW for Silver hake.



757



Freq	Depth	Temp	Sal
F5	28	1.2	31.00
F25	55	3.1	32.46
F50	77	5.5	33.20
F75	104	8.0	34.37
F95	137	10.0	35.07

Figure 7.5E. Catch distribution by depth, temperature and salinity of Silver hake.

758

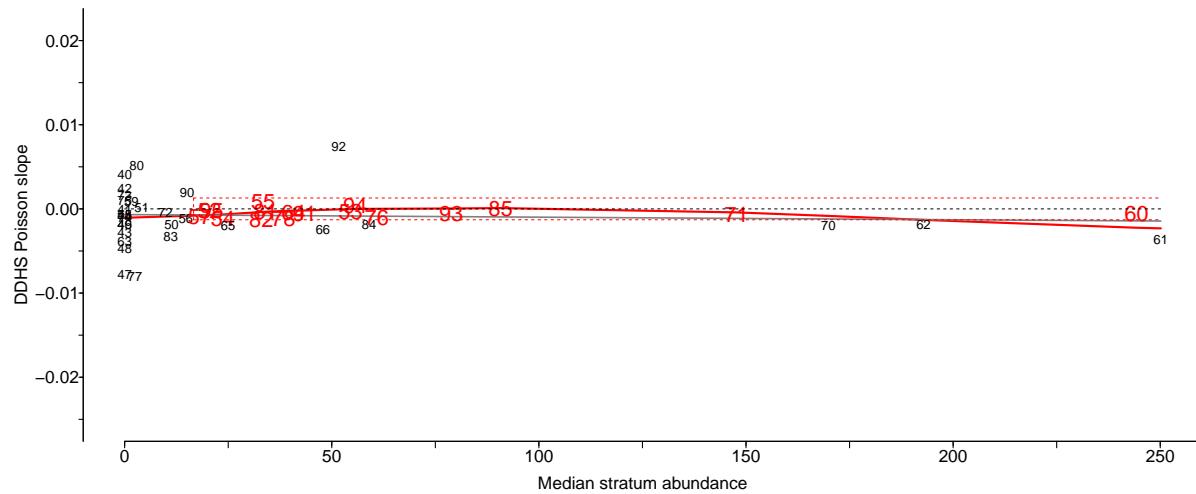


Figure 7.5F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Silver hake.

759

7.6 Pollock (Goberge) - species code 16 (category LF)

760

Scientific name: [Pollachius virens](#)

761

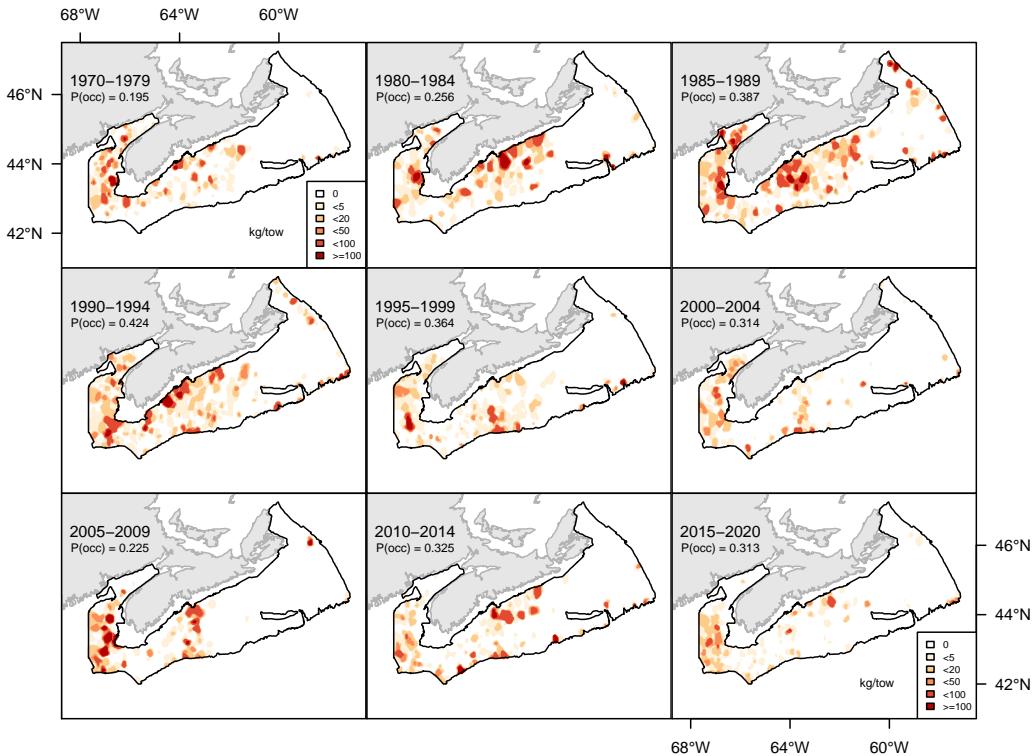


Figure 7.6A. Inverse distance weighted distribution of catch biomass (kg/tow) for Pollock.

762

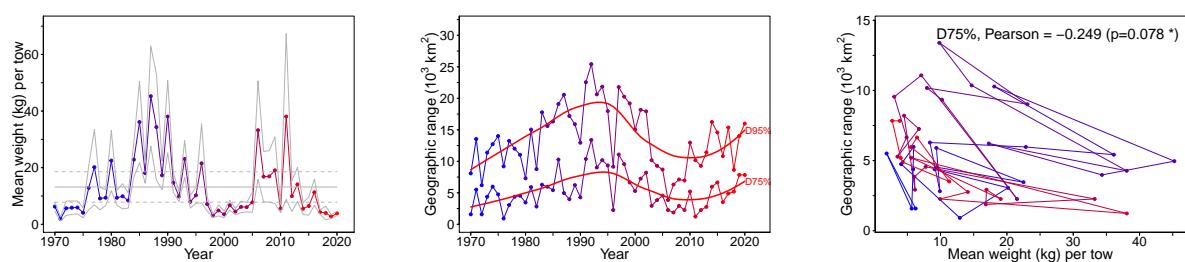


Figure 7.6B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Pollock.

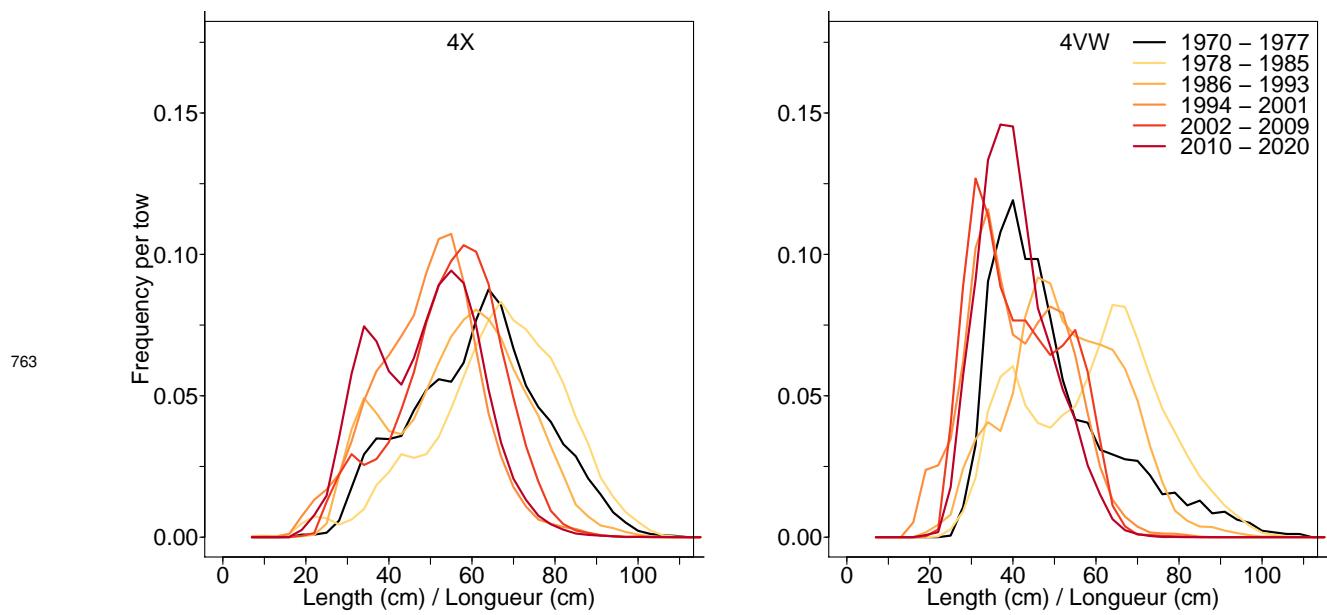


Figure 7.6C. Length frequency distribution in NAFO units 4X and 4VW for Pollock.

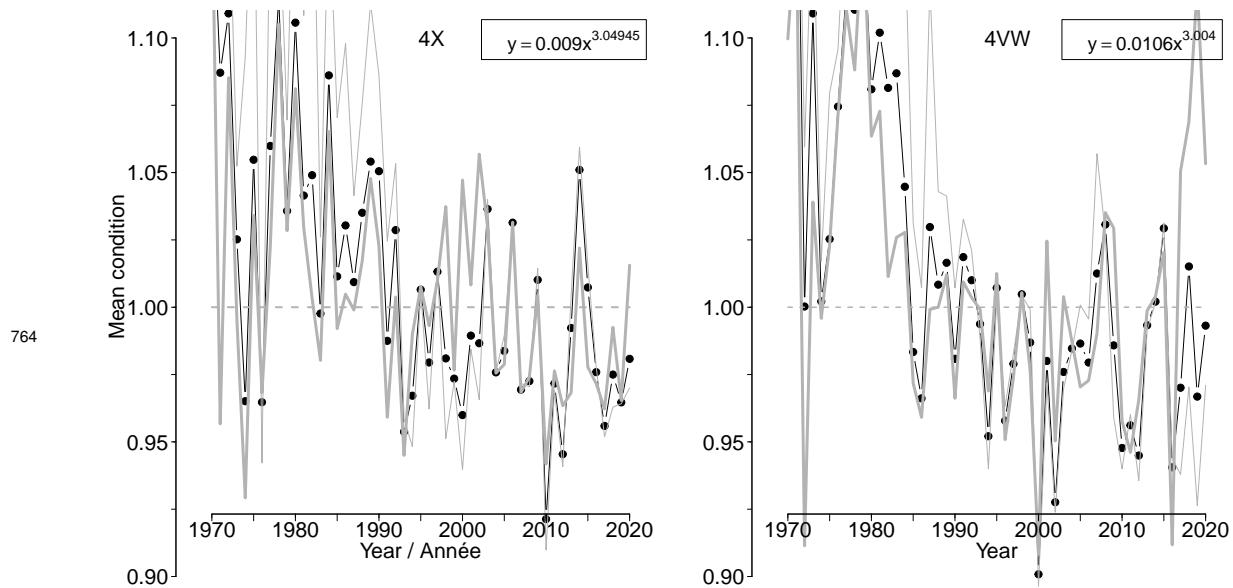
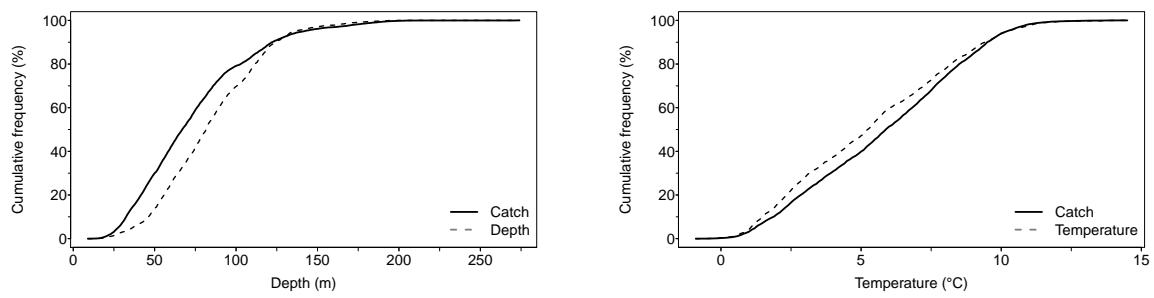
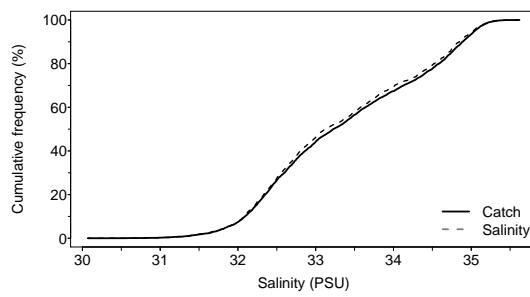


Figure 7.6D. Average fish condition in NAFO units 4X and 4VW for Pollock.



765



Freq	Depth	Temp	Sal
F5	37	1.1	31.00
F25	60	2.8	32.45
F50	82	5.3	33.14
F75	108	7.7	34.33
F95	137	10.0	35.03

Figure 7.6E. Catch distribution by depth, temperature and salinity of Pollock.

766

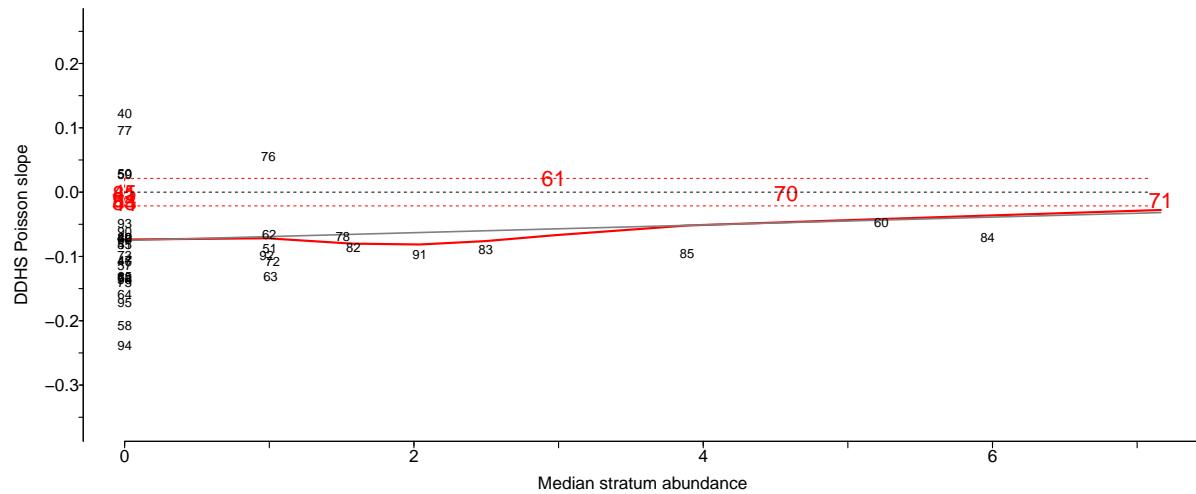


Figure 7.6F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Pollock.

767 **7.7 Atlantic redfishes (Sébastes de l'Atlantique) - species code 23 (category LF)**

768 Scientific name: [Sebastes](#)

769

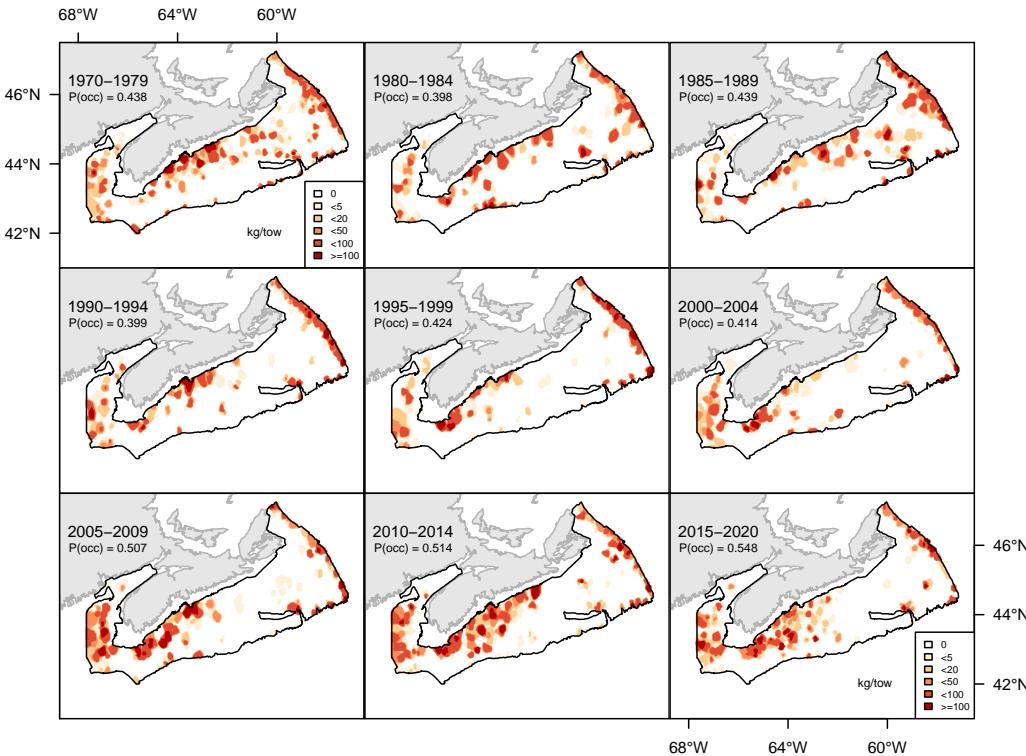


Figure 7.7A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic redfishes.

770

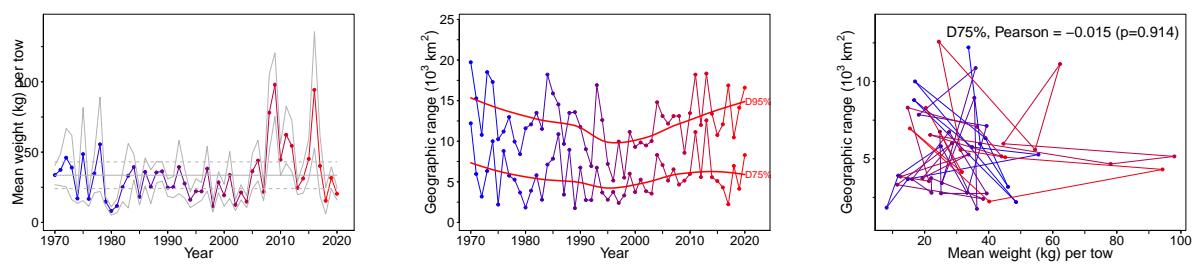


Figure 7.7B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic redfishes.

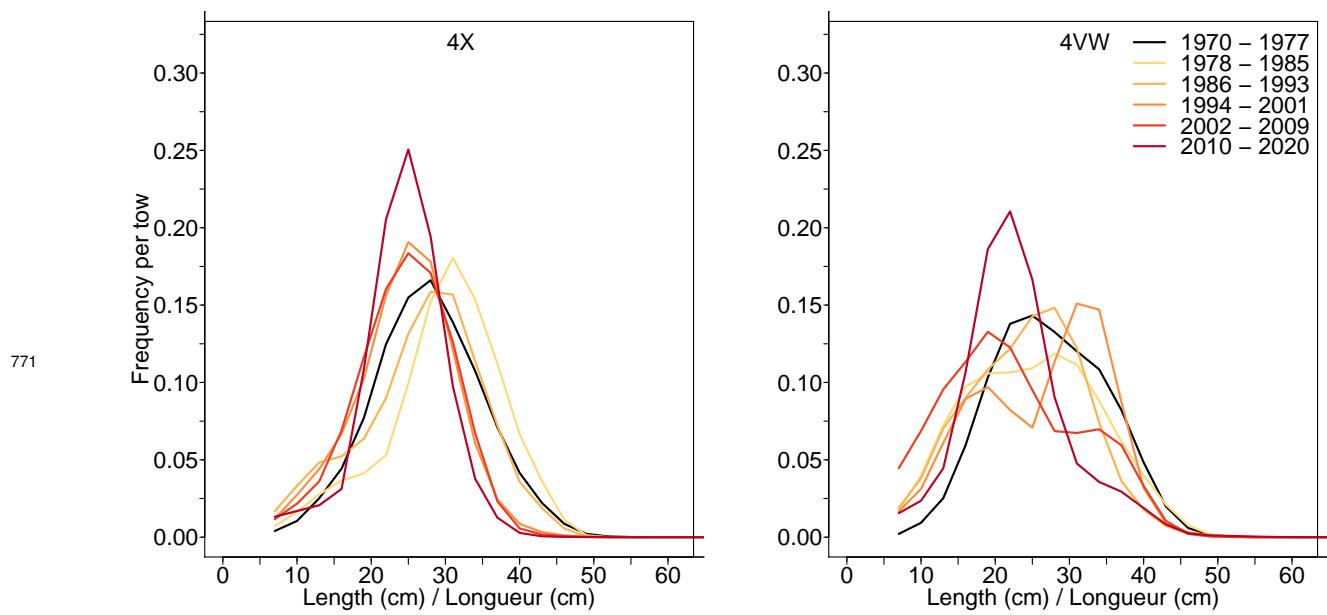


Figure 7.7C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic redfishes.

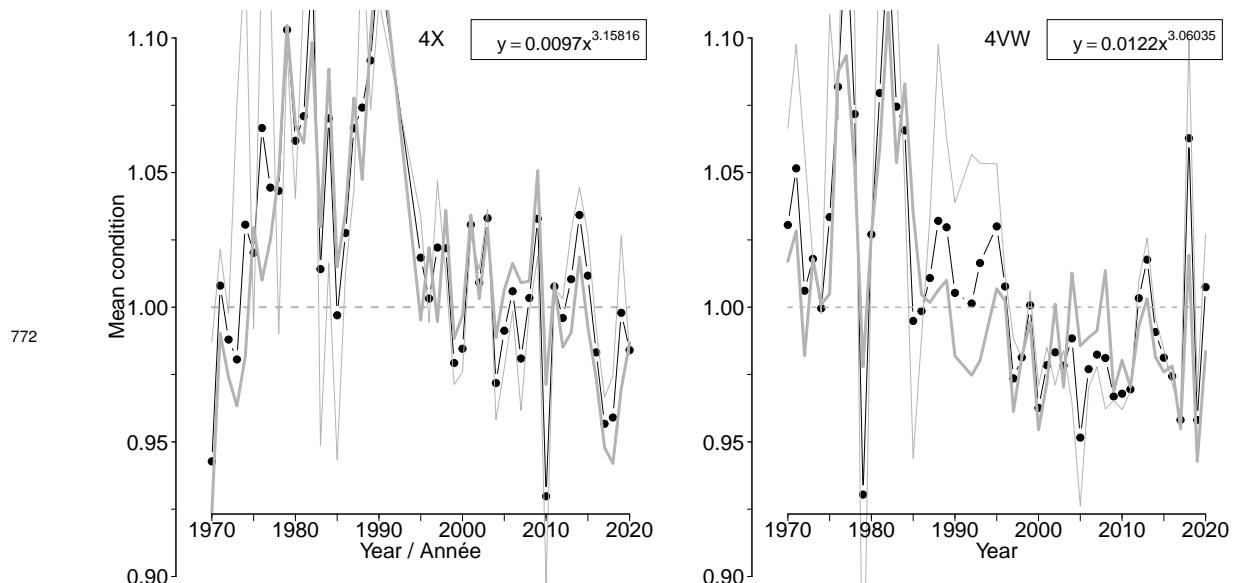
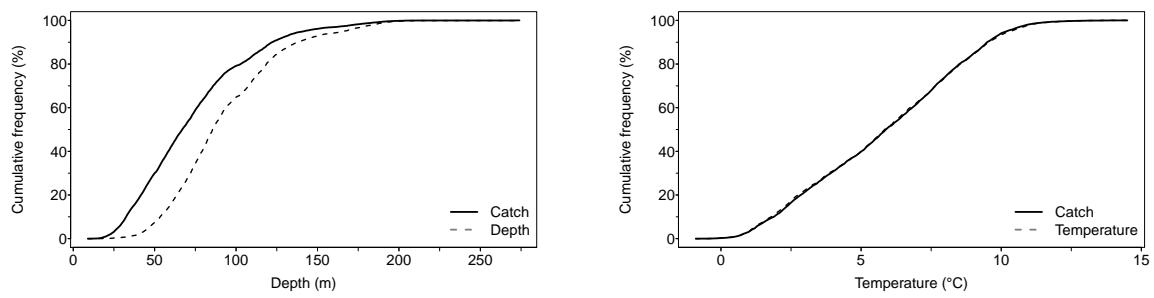
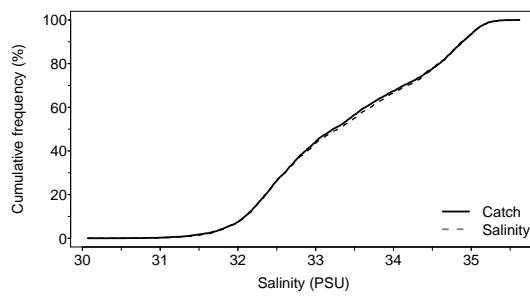


Figure 7.7D. Average fish condition in NAFO units 4X and 4VW for Atlantic redfishes.



773



Freq	Depth	Temp	Sal
F5	47	1.2	31.00
F25	68	3.4	32.48
F50	86	5.9	33.29
F75	114	8.1	34.41
F95	166	10.0	35.05

Figure 7.7E. Catch distribution by depth, temperature and salinity of Atlantic redfishes.

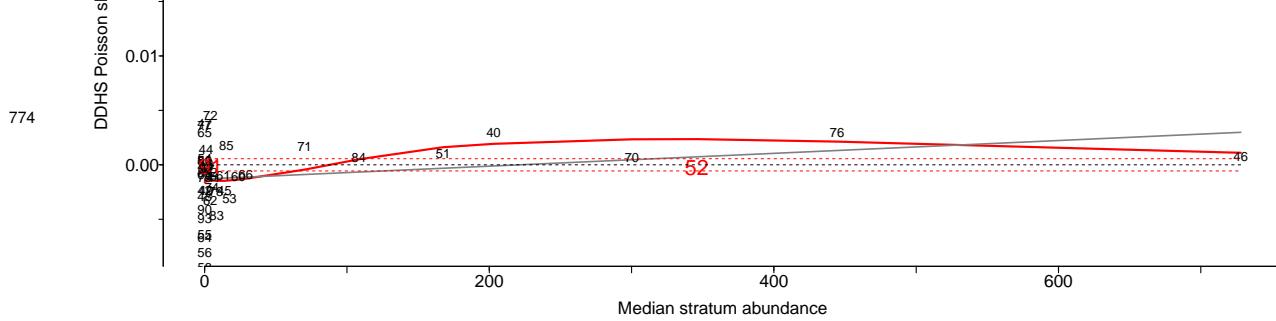


Figure 7.7F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic redfishes.

775

7.8 Atlantic halibut (Flétan de l'Atlantique) - species code 30 (category LF)

776

Scientific name: [Hippoglossus hippoglossus](#)

777

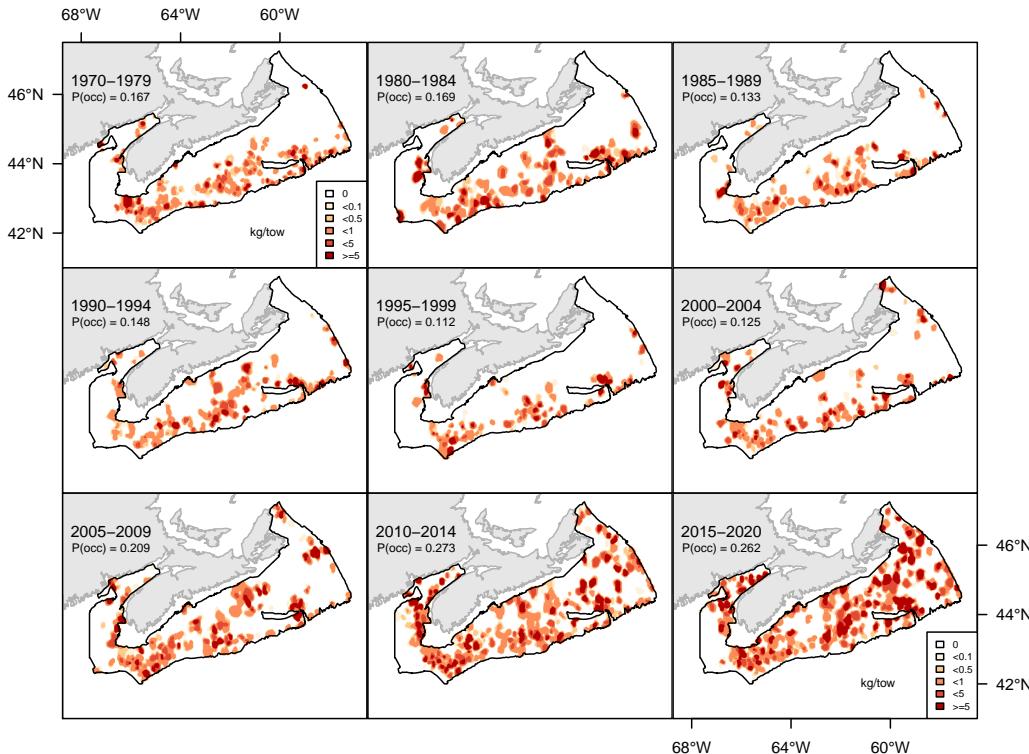


Figure 7.8A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic halibut.

778

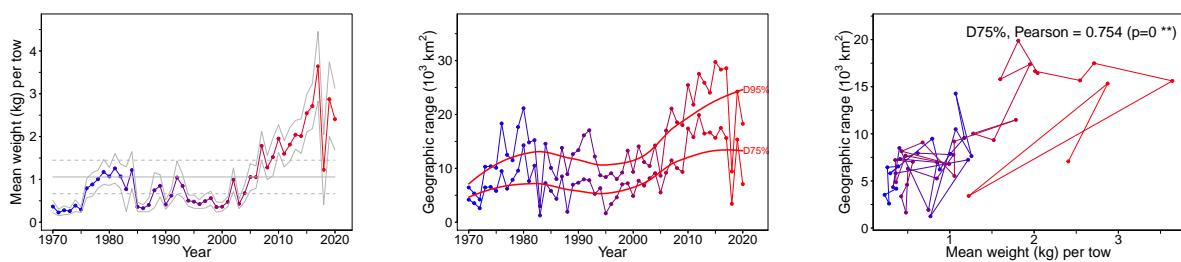


Figure 7.8B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic halibut.

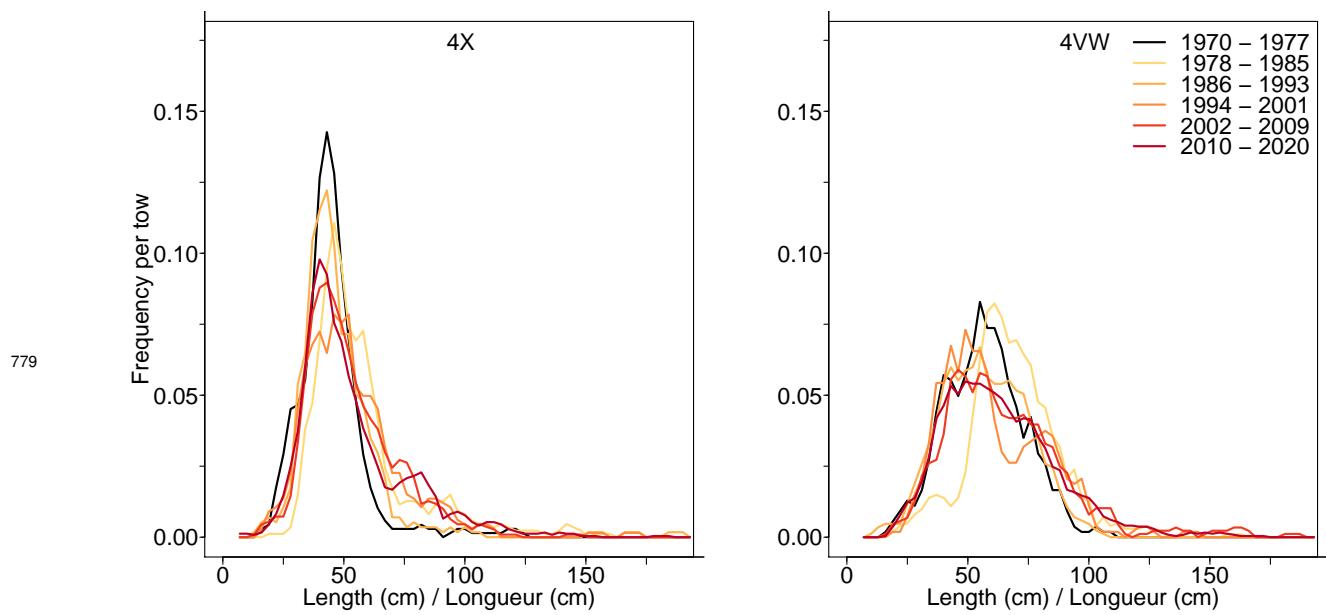


Figure 7.8C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic halibut.

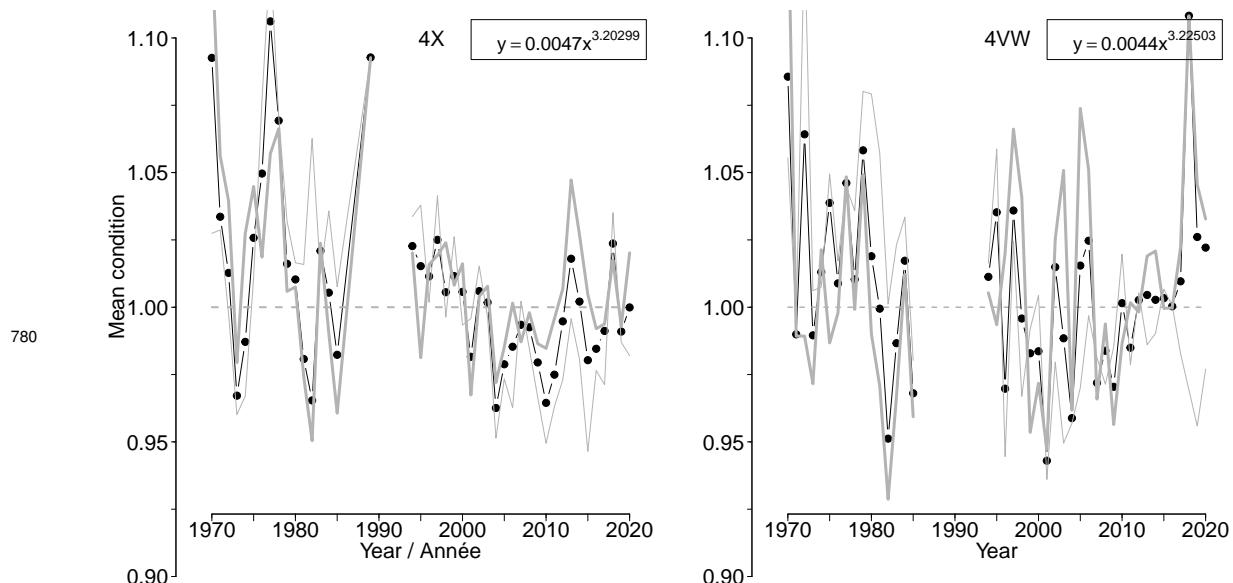
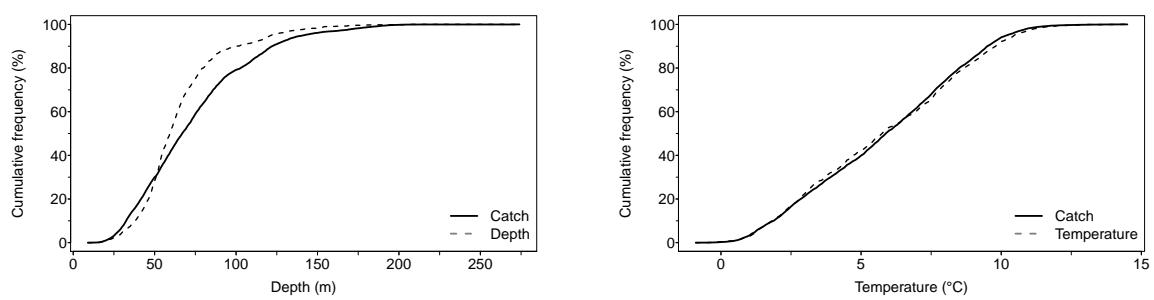
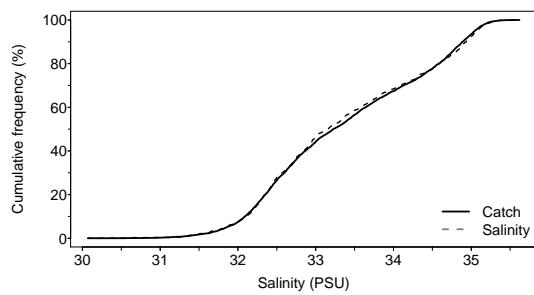


Figure 7.8D. Average fish condition in NAFO units 4X and 4VW for Atlantic halibut.



781



Freq	Depth	Temp	Sal
F5	31	1.3	31.00
F25	49	3.2	32.45
F50	60	5.8	33.16
F75	75	8.3	34.34
F95	122	10.0	35.08

Figure 7.8E. Catch distribution by depth, temperature and salinity of Atlantic halibut.

782

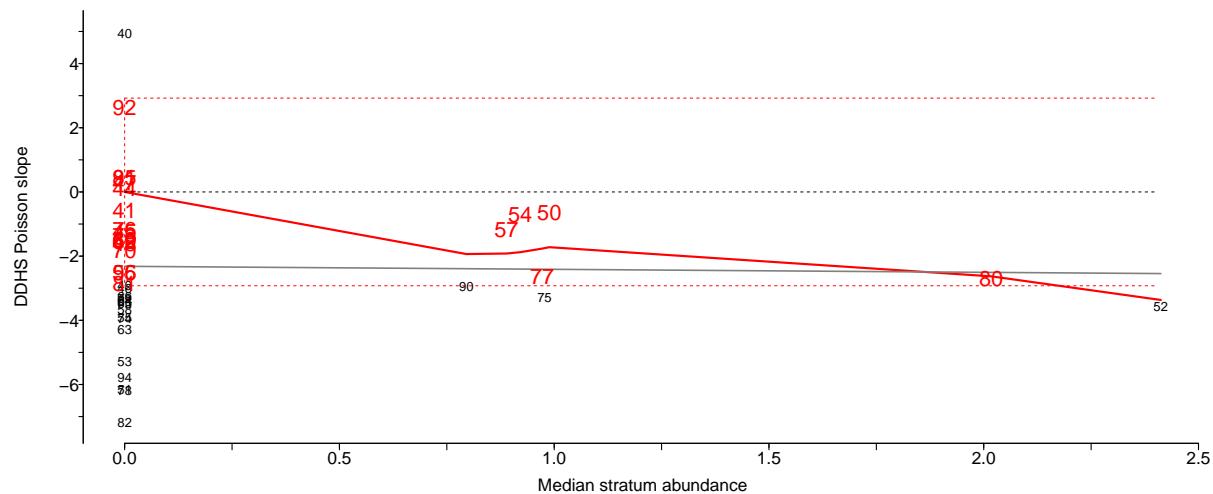


Figure 7.8F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic halibut.

783

7.9 American plaice (*Ple canadienne*) - species code 40 (category LF)

784

Scientific name: [Hippoglossoides platessoides](#)

785

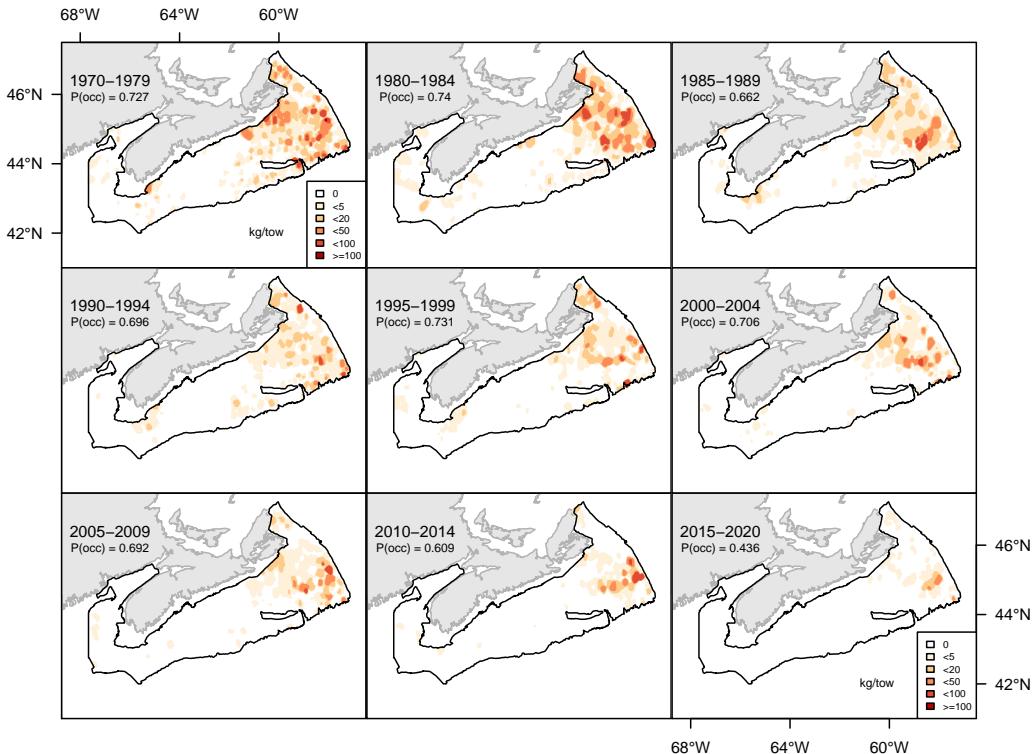


Figure 7.9A. Inverse distance weighted distribution of catch biomass (kg/tow) for American plaice.

786

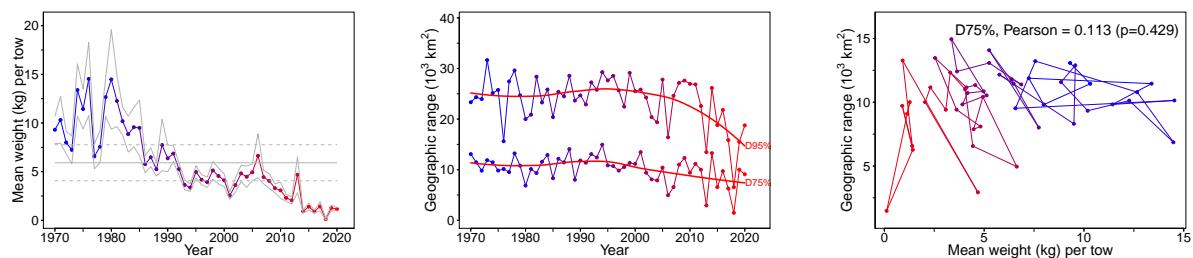


Figure 7.9B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American plaice.

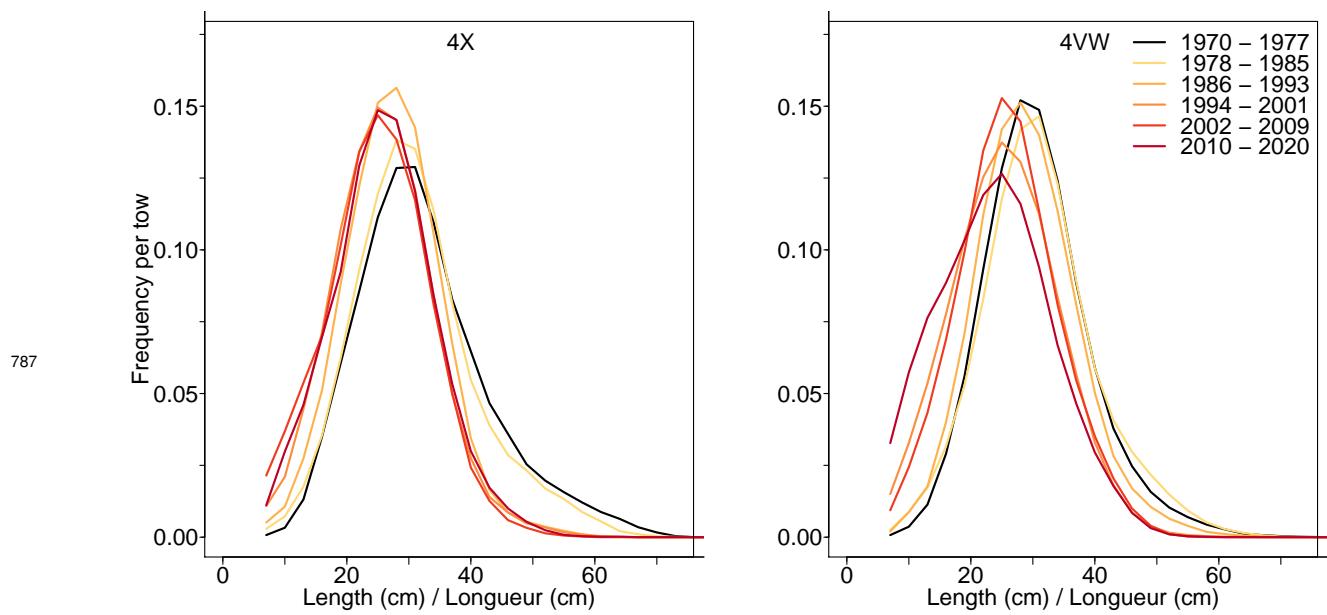


Figure 7.9C. Length frequency distribution in NAFO units 4X and 4VW for American plaice.

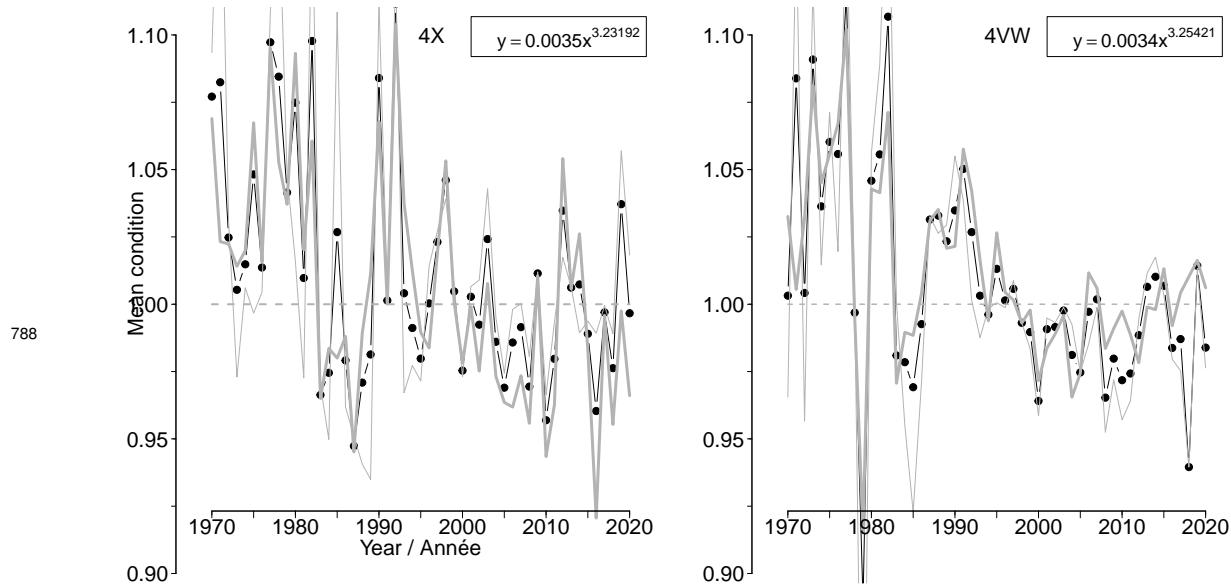
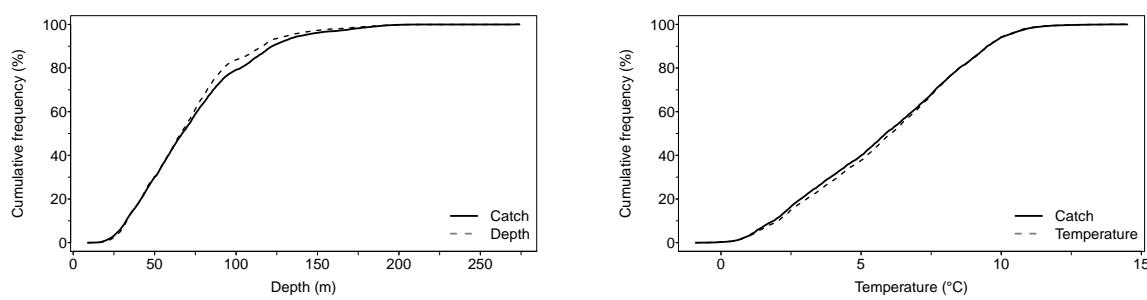
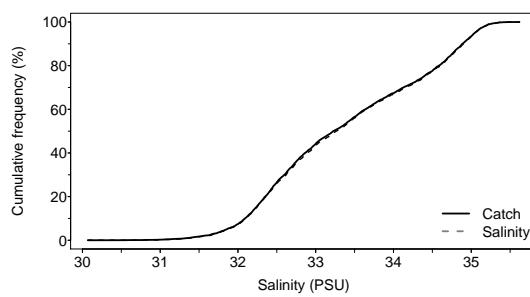


Figure 7.9D. Average fish condition in NAFO units 4X and 4VW for American plaice.



789



Freq	Depth	Temp	Sal
F5	29	1.3	31.00
F25	46	3.7	32.48
F50	67	6.1	33.27
F75	87	8.1	34.41
F95	133	10.0	35.05

Figure 7.9E. Catch distribution by depth, temperature and salinity of American plaice.

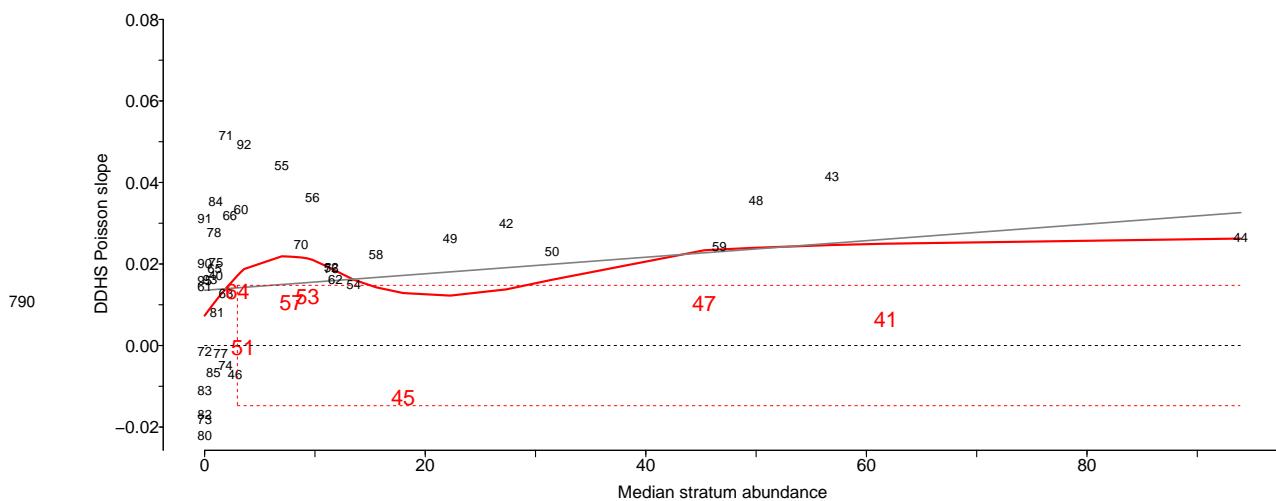


Figure 7.9F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for American plaice.

791

7.10 Witch flounder (*Ple grise*) - species code 41 (category LF)

792

Scientific name: [Glyptocephalus cynoglossus](#)

793

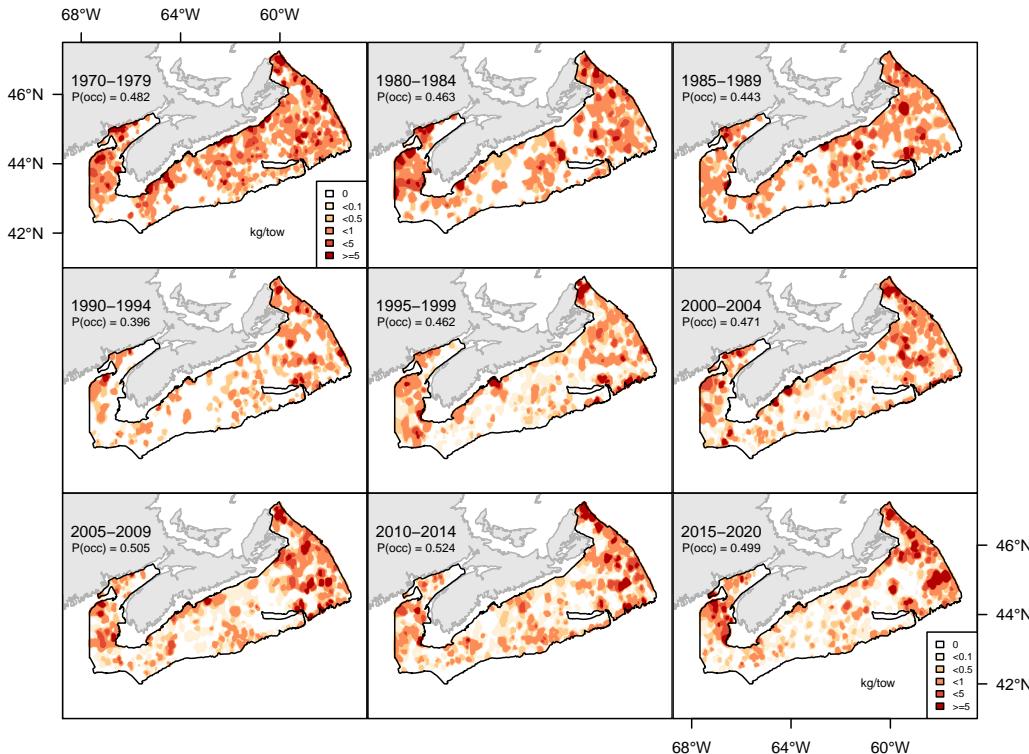


Figure 7.10A. Inverse distance weighted distribution of catch biomass (kg/tow) for Witch flounder.

794

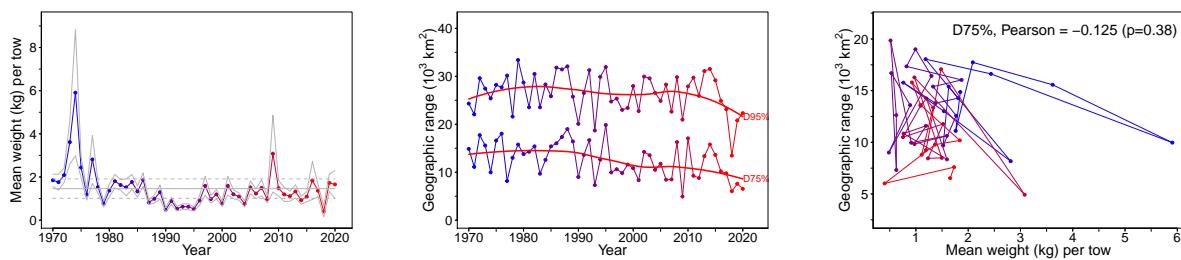


Figure 7.10B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Witch flounder.

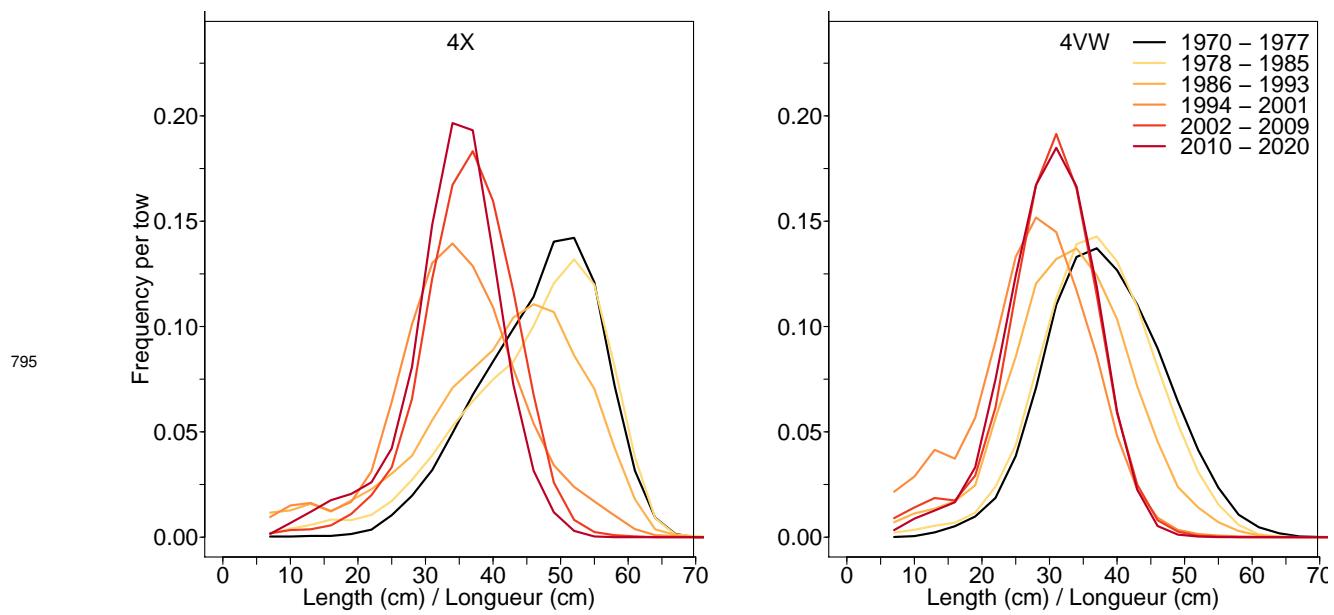


Figure 7.10C. Length frequency distribution in NAFO units 4X and 4VW for Witch flounder.

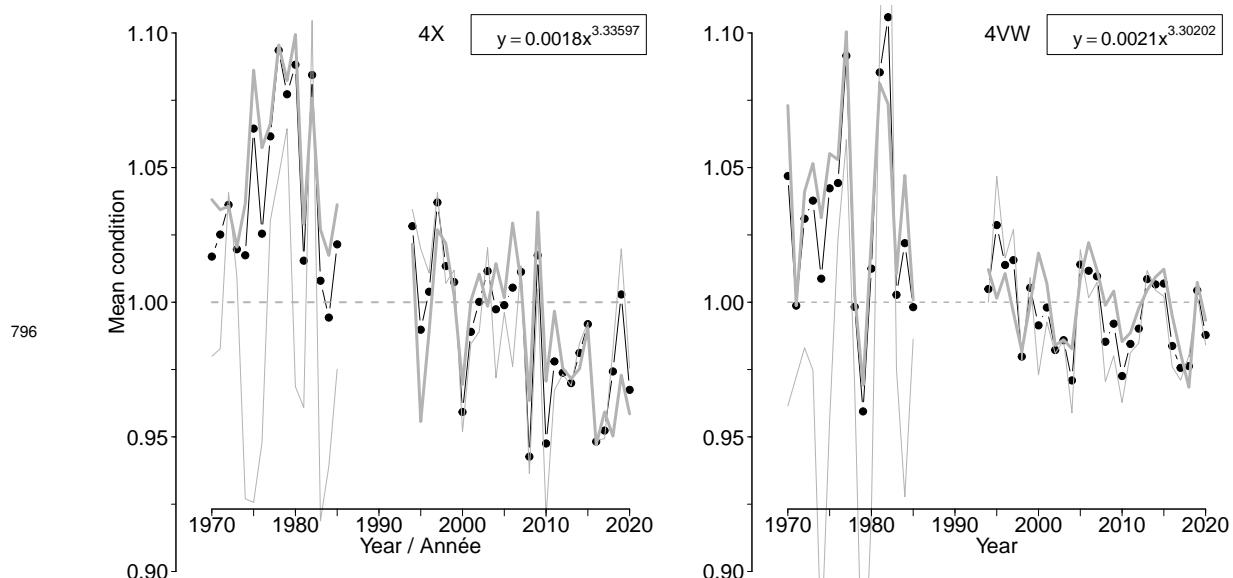
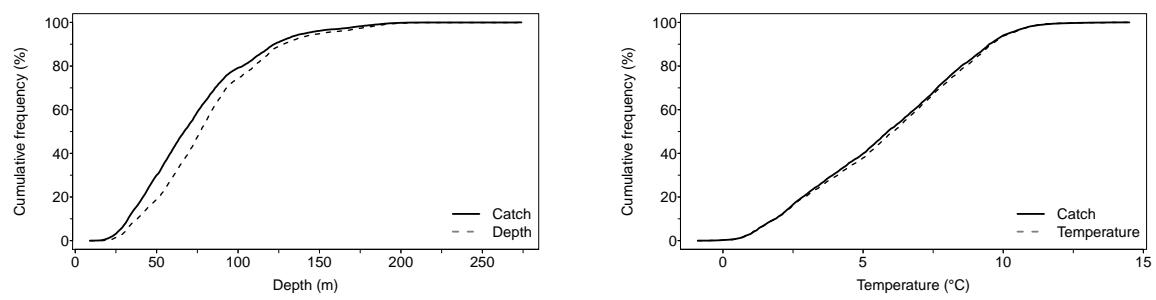
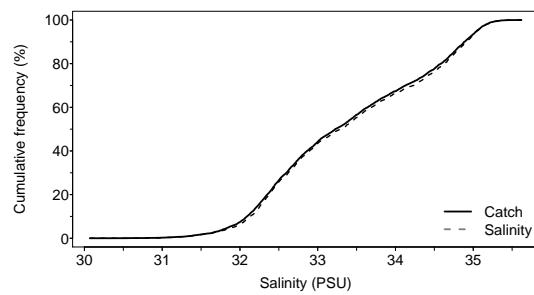


Figure 7.10D. Average fish condition in NAFO units 4X and 4VW for Witch flounder.



797



Freq	Depth	Temp	Sal
F5	32	1.3	31.00
F25	57	3.5	32.49
F50	77	6.1	33.30
F75	102	8.2	34.45
F95	152	10.0	35.06

Figure 7.10E. Catch distribution by depth, temperature and salinity of Witch flounder.

798

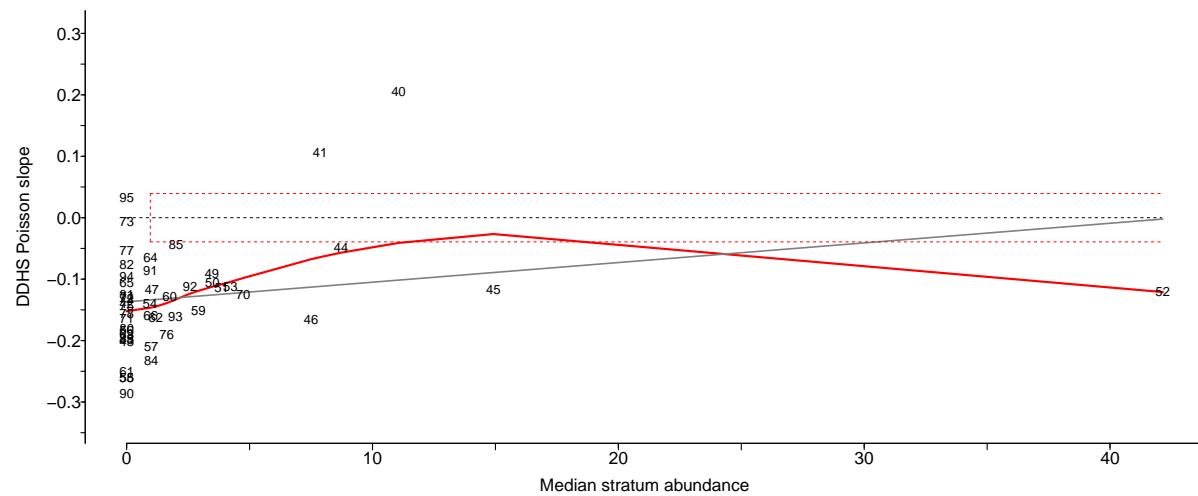


Figure 7.10F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Witch flounder.

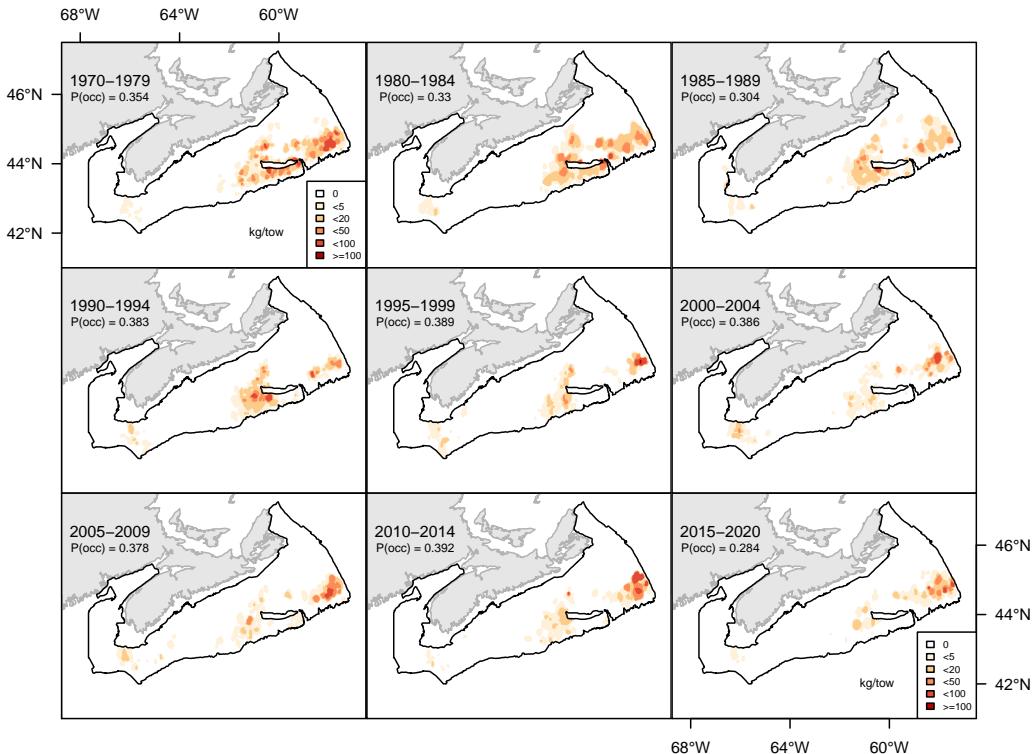
799

7.11 Yellowtail flounder (Limande à queue jaune) - species code 42 (category LF)

800

Scientific name: [Limanda ferruginea](#)

801



802

Figure 7.11A. Inverse distance weighted distribution of catch biomass (kg/tow) for Yellowtail flounder.

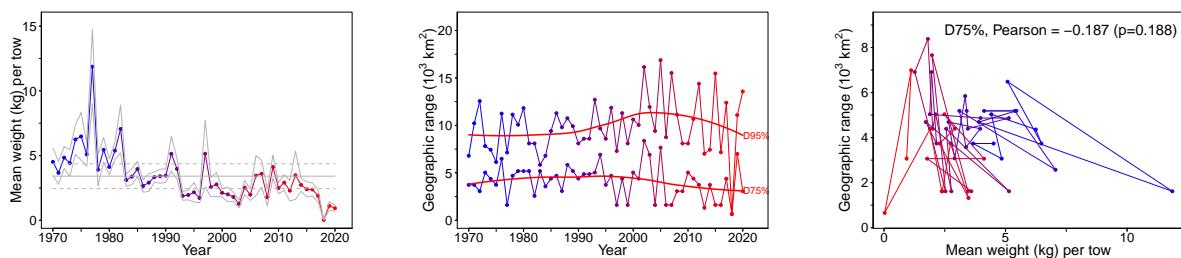


Figure 7.11B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Yellowtail flounder.

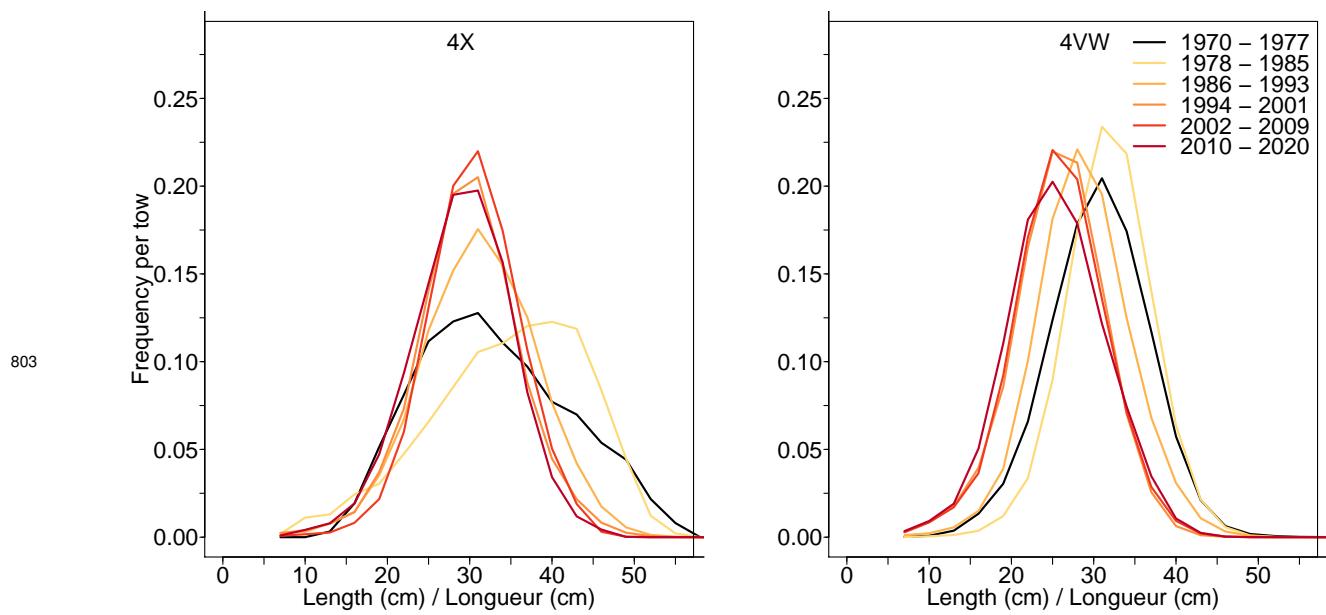


Figure 7.11C. Length frequency distribution in NAFO units 4X and 4VW for Yellowtail flounder.

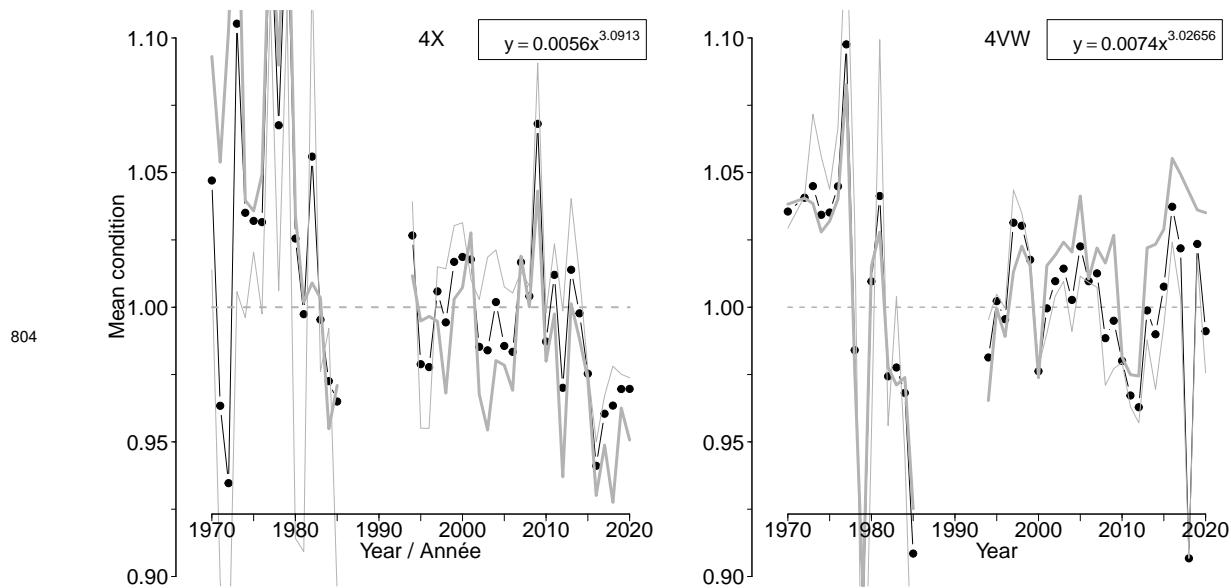


Figure 7.11D. Average fish condition in NAFO units 4X and 4VW for Yellowtail flounder.

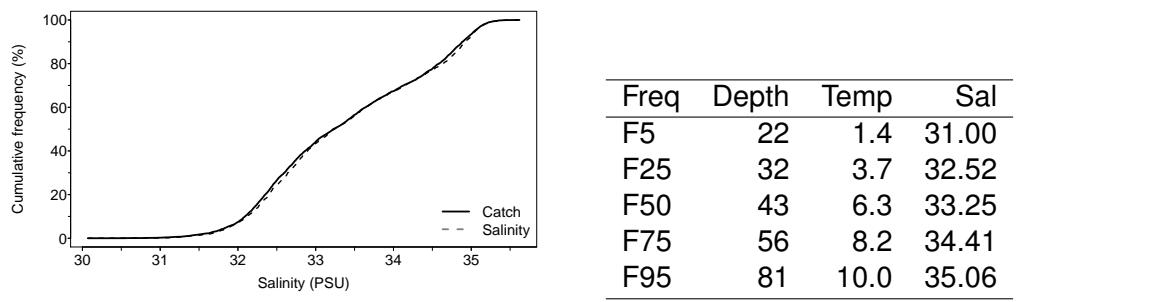
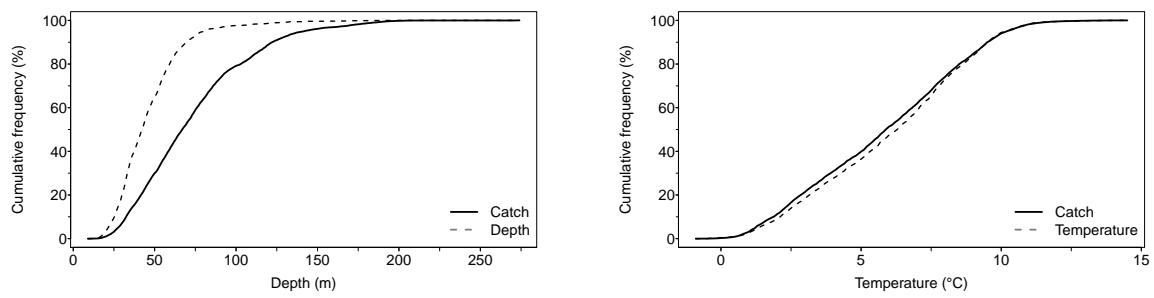


Figure 7.11E. Catch distribution by depth, temperature and salinity of Yellowtail flounder.

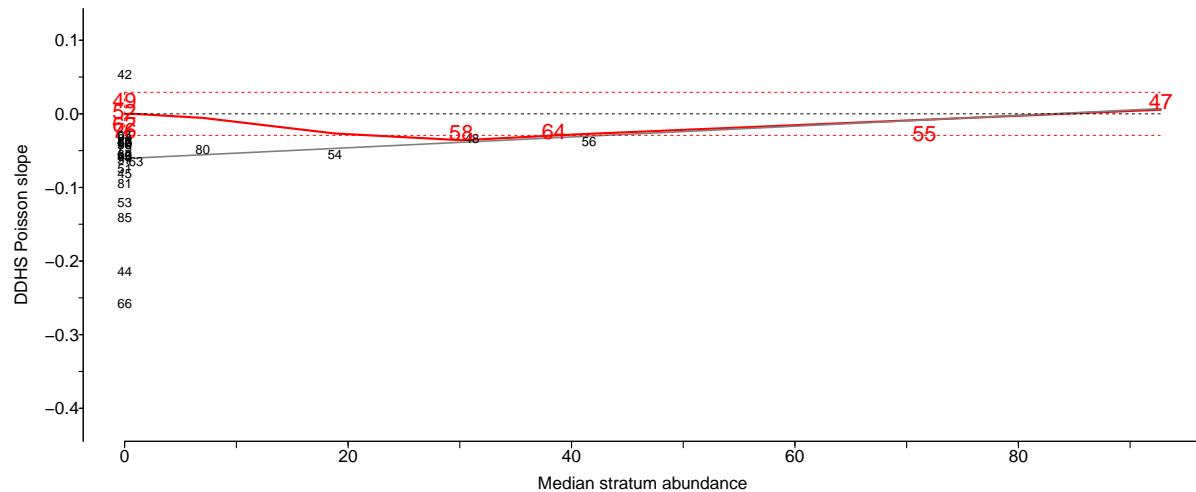


Figure 7.11F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Yellowtail flounder.

807 **7.12 Winter flounder (Limande-plie rouge) - species code 43 (category LF)**

808 Scientific name: [Pseudopleuronectes americanus](#)

809

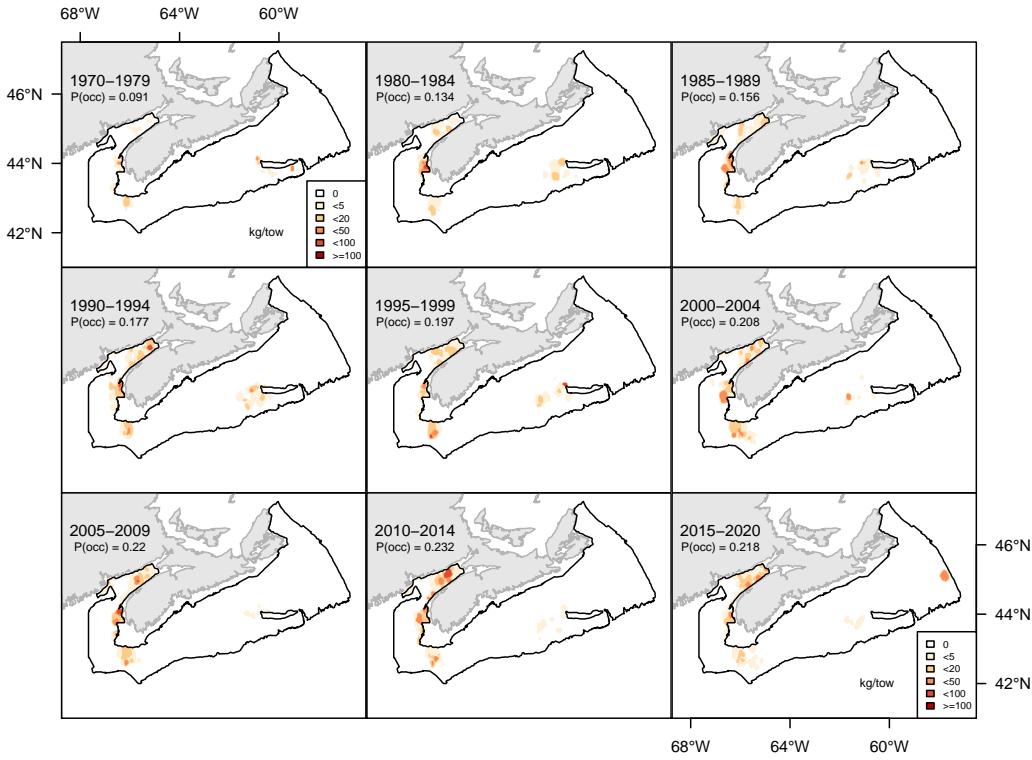


Figure 7.12A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter flounder.

810

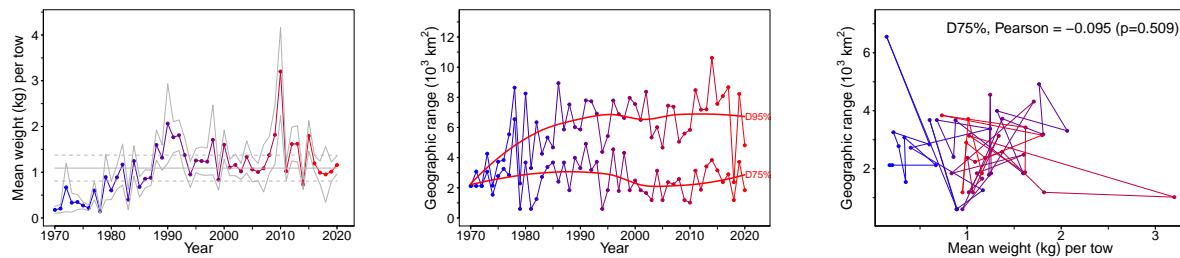


Figure 7.12B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter flounder.

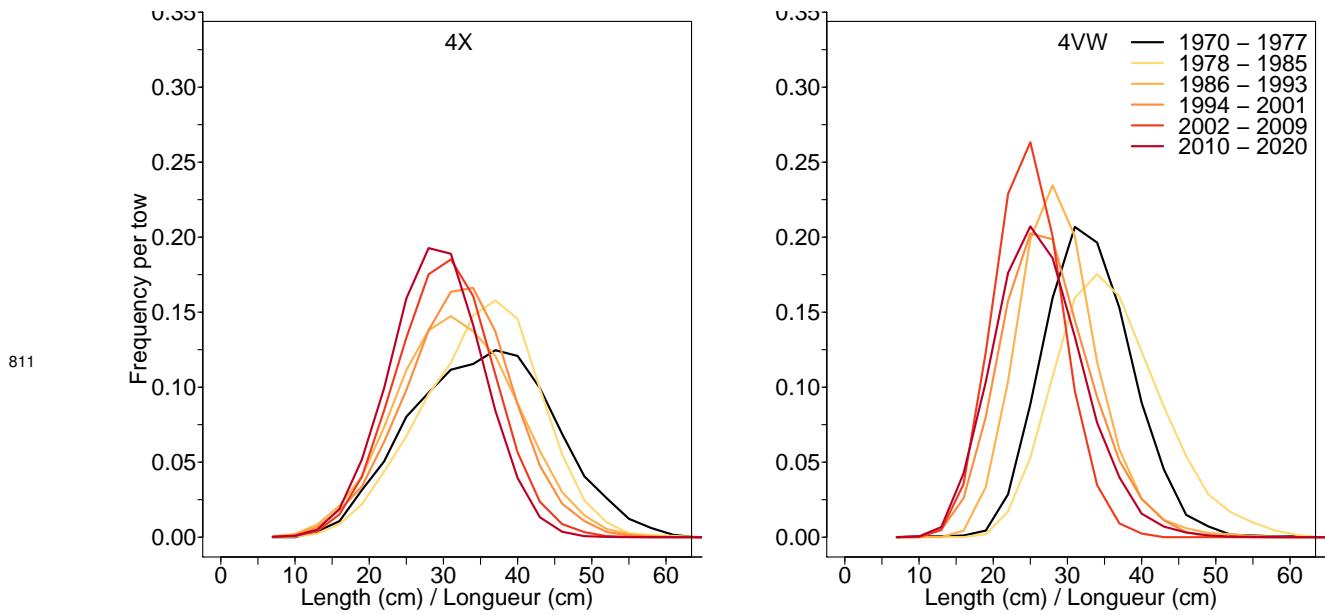


Figure 7.12C. Length frequency distribution in NAFO units 4X and 4VW for Winter flounder.

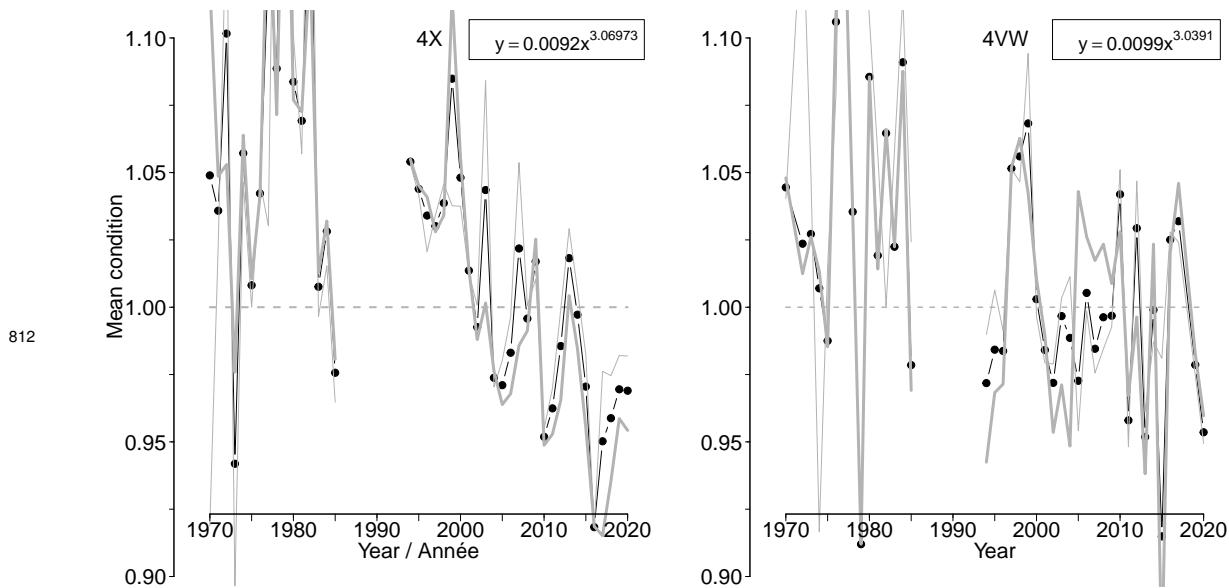
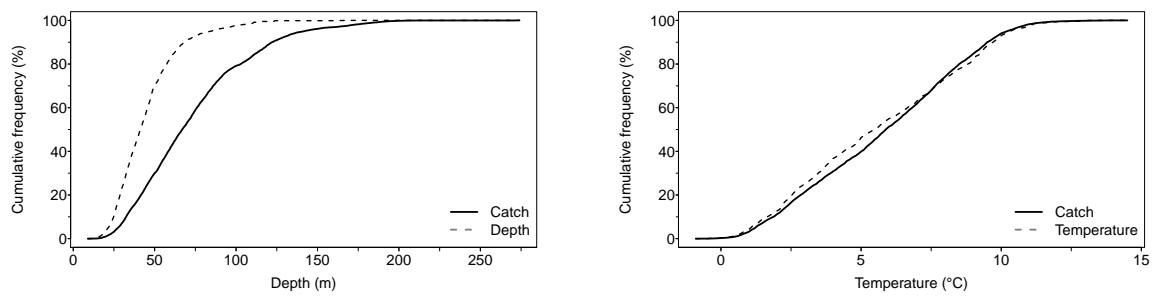
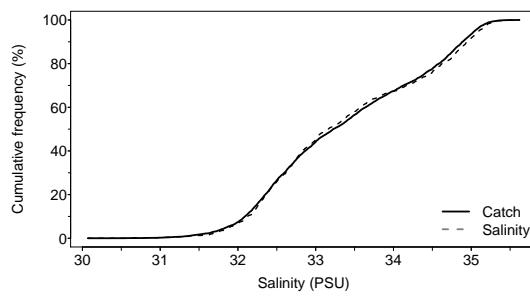


Figure 7.12D. Average fish condition in NAFO units 4X and 4VW for Winter flounder.



813



Freq	Depth	Temp	Sal
F5	22	1.1	31.00
F25	31	3.0	32.48
F50	42	5.5	33.17
F75	54	8.3	34.47
F95	84	10.0	35.10

Figure 7.12E. Catch distribution by depth, temperature and salinity of Winter flounder.

814

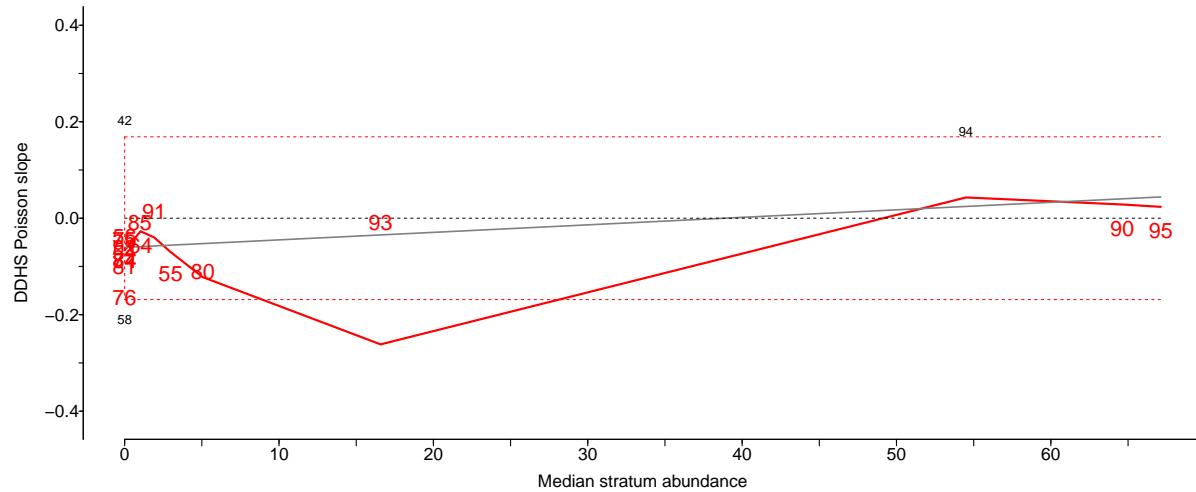


Figure 7.12F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Winter flounder.

815

7.13 Atlantic wolffish (*Loup atlantique*) - species code 50 (category LF)

816

Scientific name: [Anarhichas lupus](#)

817

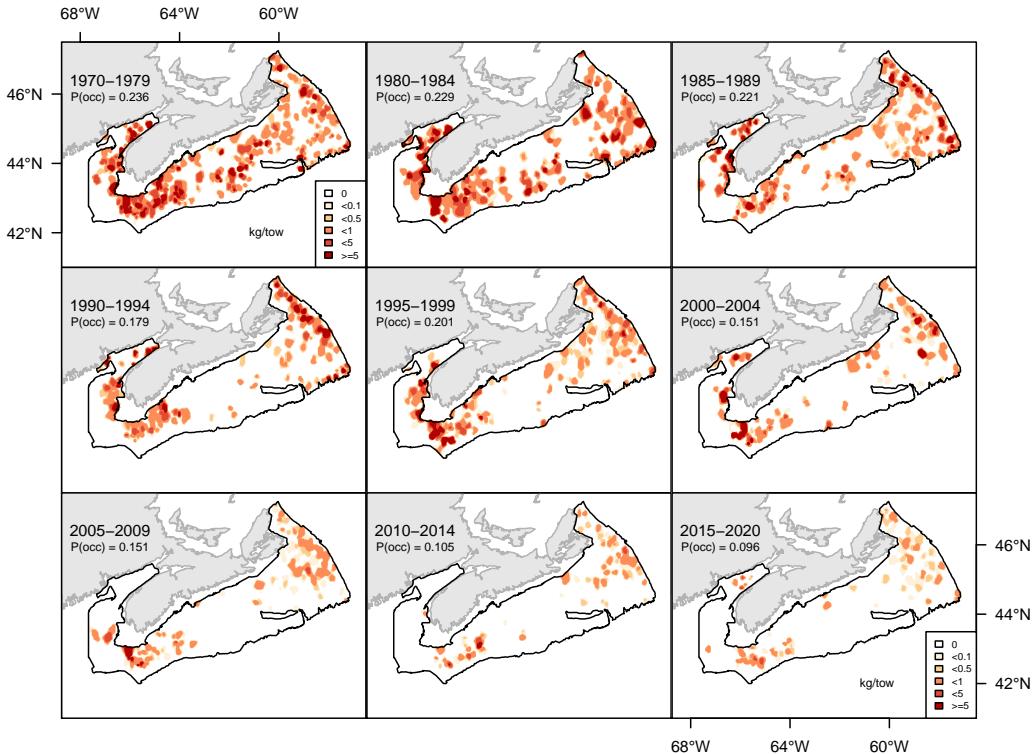


Figure 7.13A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic wolffish.

818

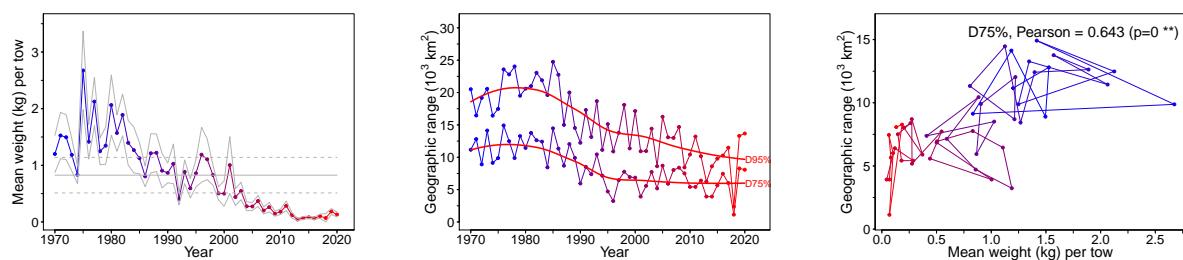


Figure 7.13B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic wolffish.

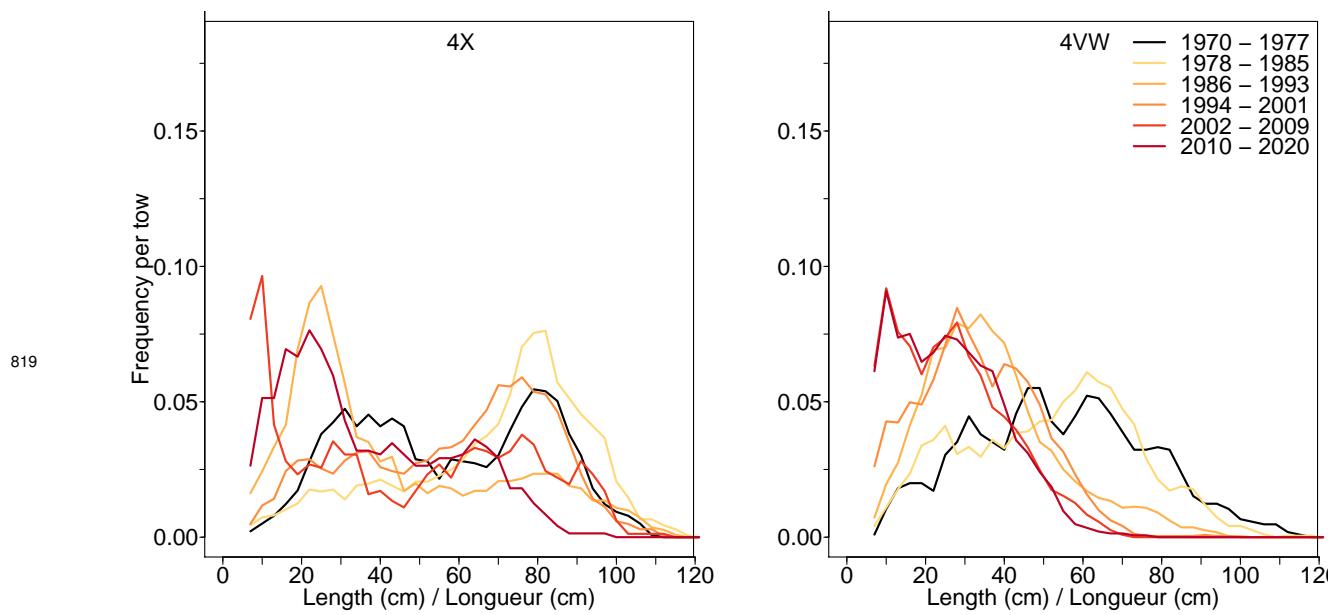


Figure 7.13C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic wolffish.

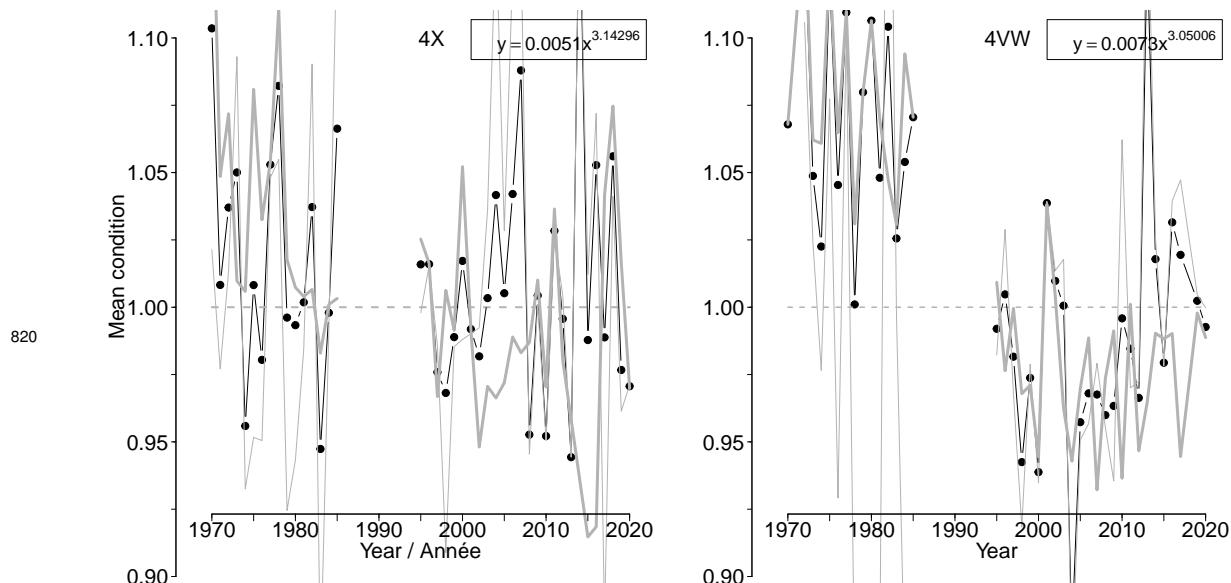
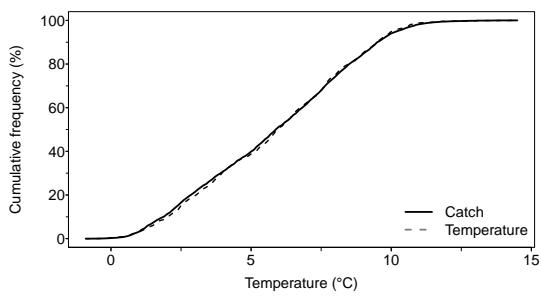
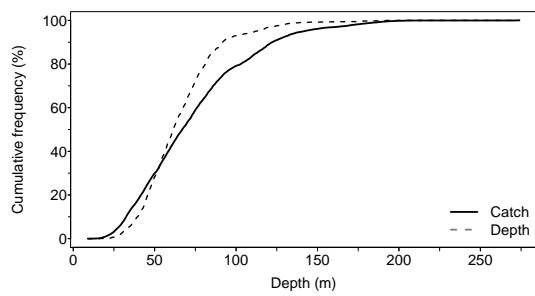
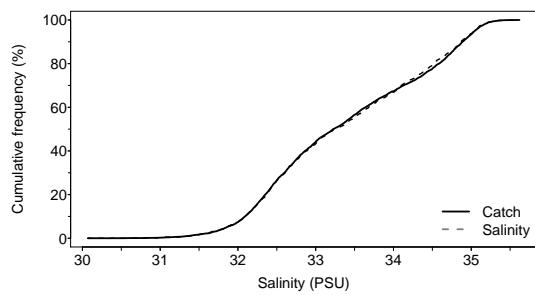


Figure 7.13D. Average fish condition in NAFO units 4X and 4VW for Atlantic wolffish.



821



Freq	Depth	Temp	Sal
F5	34	1.4	31.00
F25	49	3.6	32.48
F50	62	6.0	33.25
F75	77	8.1	34.33
F95	112	10.0	35.05

Figure 7.13E. Catch distribution by depth, temperature and salinity of Atlantic wolffish.

822

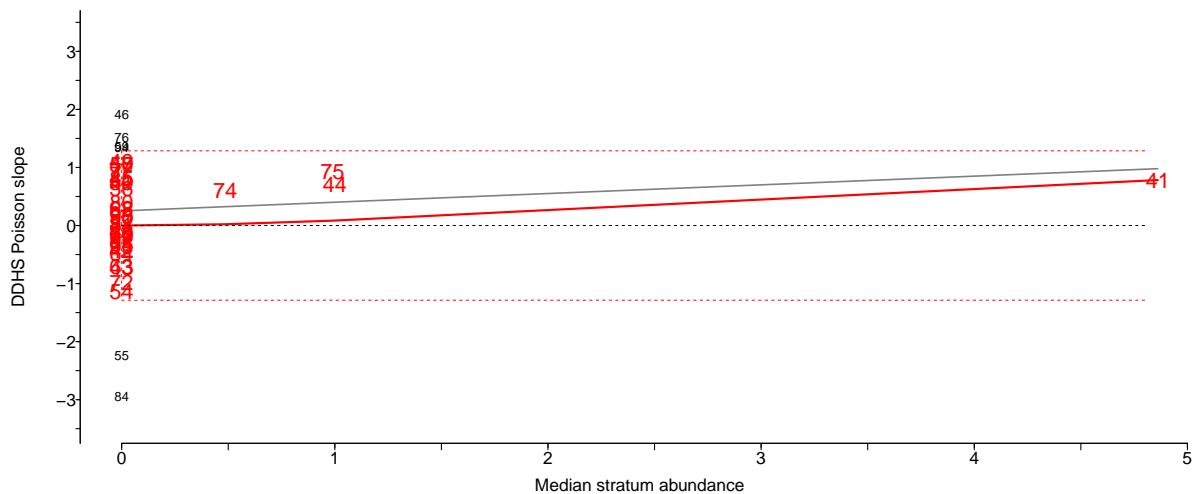


Figure 7.13F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic wolffish.

823

7.14 Atlantic herring (Hareng de l'Atlantique) - species code 60 (category LF)

824

Scientific name: [Clupea harengus](#)

825

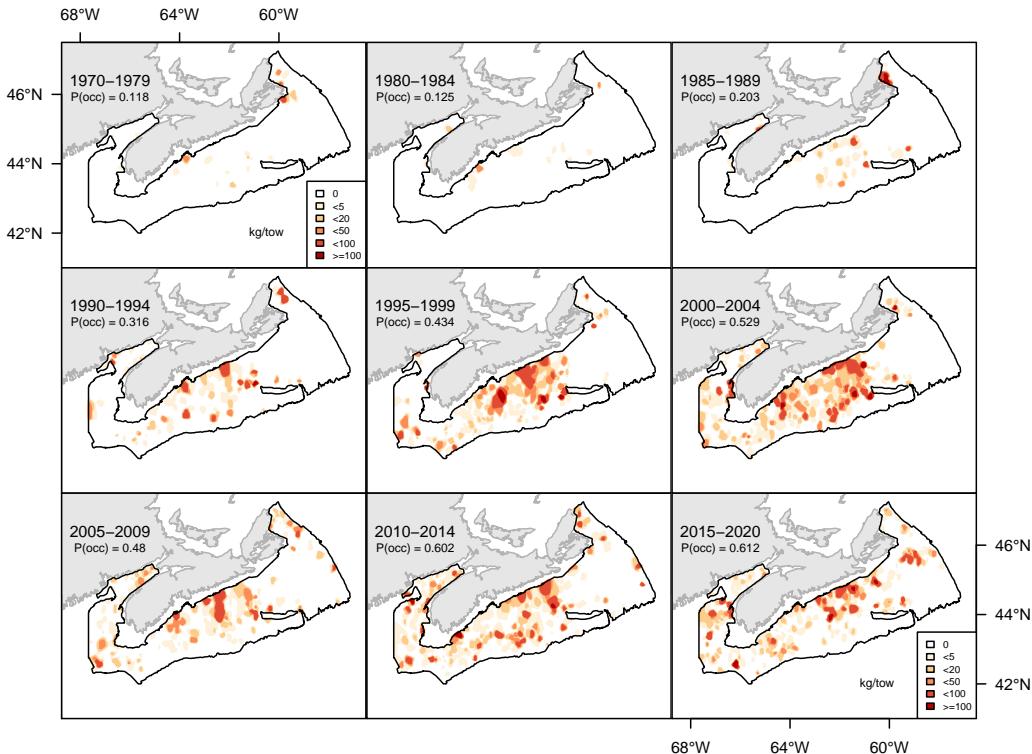


Figure 7.14A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic herring.

826

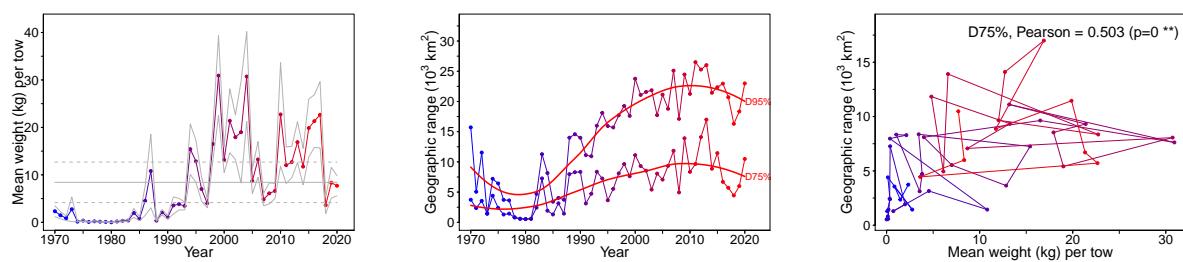


Figure 7.14B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic herring.

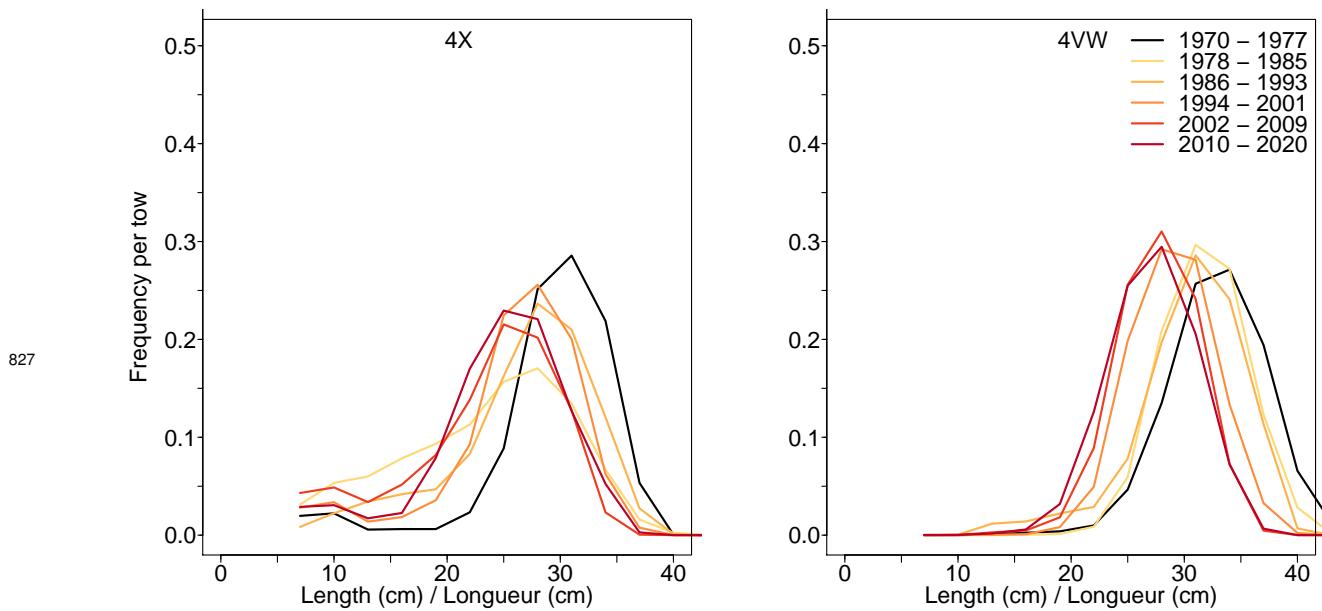


Figure 7.14C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic herring.

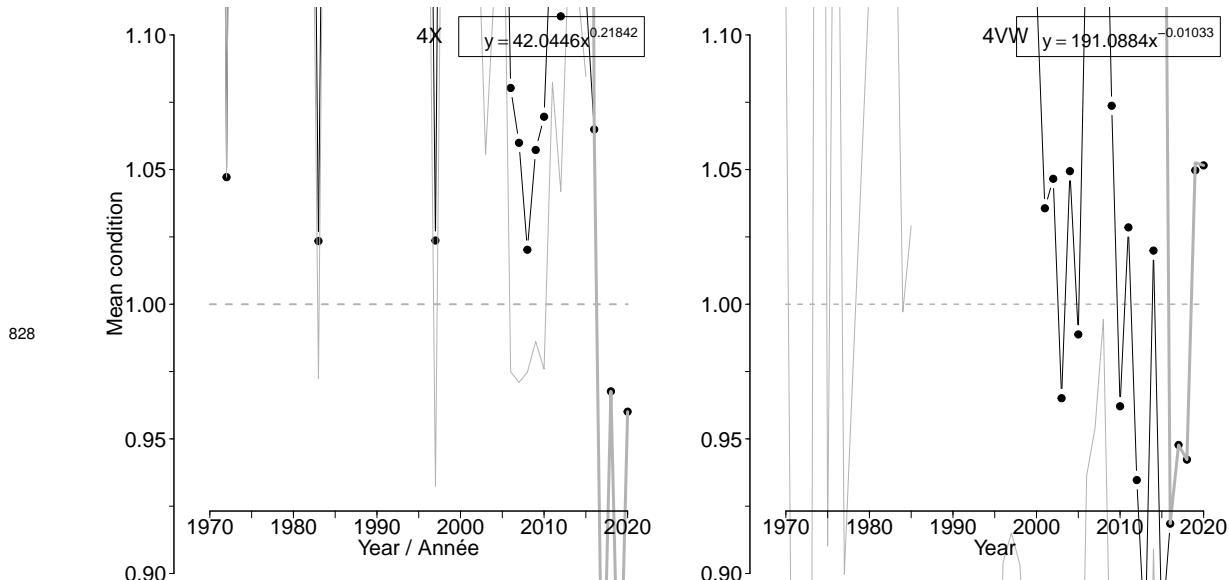
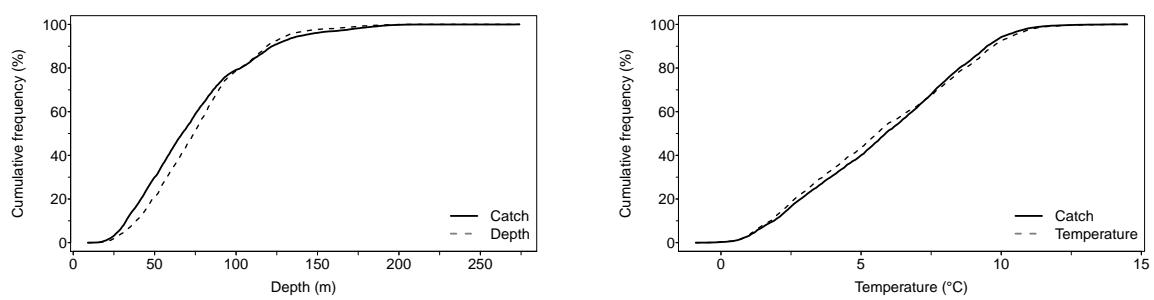
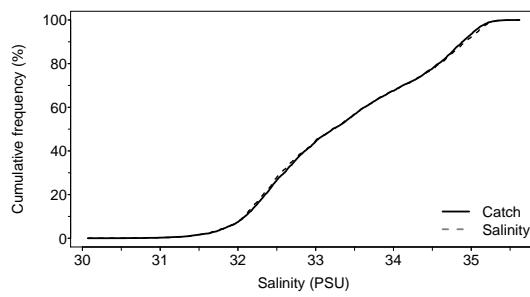


Figure 7.14D. Average fish condition in NAFO units 4X and 4VW for Atlantic herring.



829



Freq	Depth	Temp	Sal
F5	32	1.2	31.00
F25	54	3.2	32.45
F50	74	5.6	33.22
F75	95	8.3	34.38
F95	132	10.0	35.10

Figure 7.14E. Catch distribution by depth, temperature and salinity of Atlantic herring.

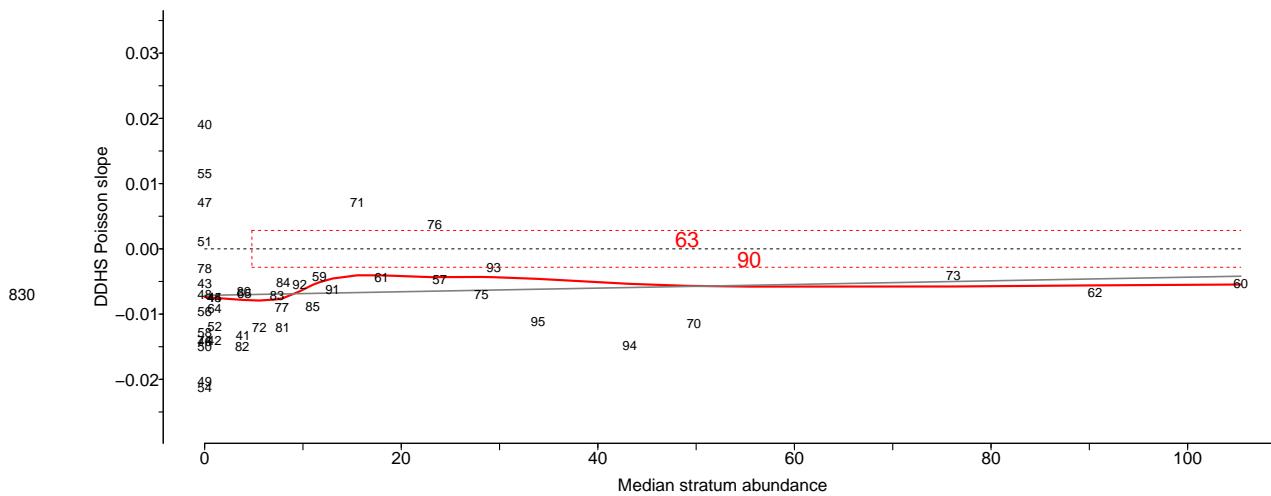


Figure 7.14F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic herring.

831 **7.15 Longhorn sculpin (Chaboisseau à dix-huit épines) - species code 300 (category**
 832 **LF)**

833 Scientific name: [Myoxocephalus octodecemspiniferus](#)

834

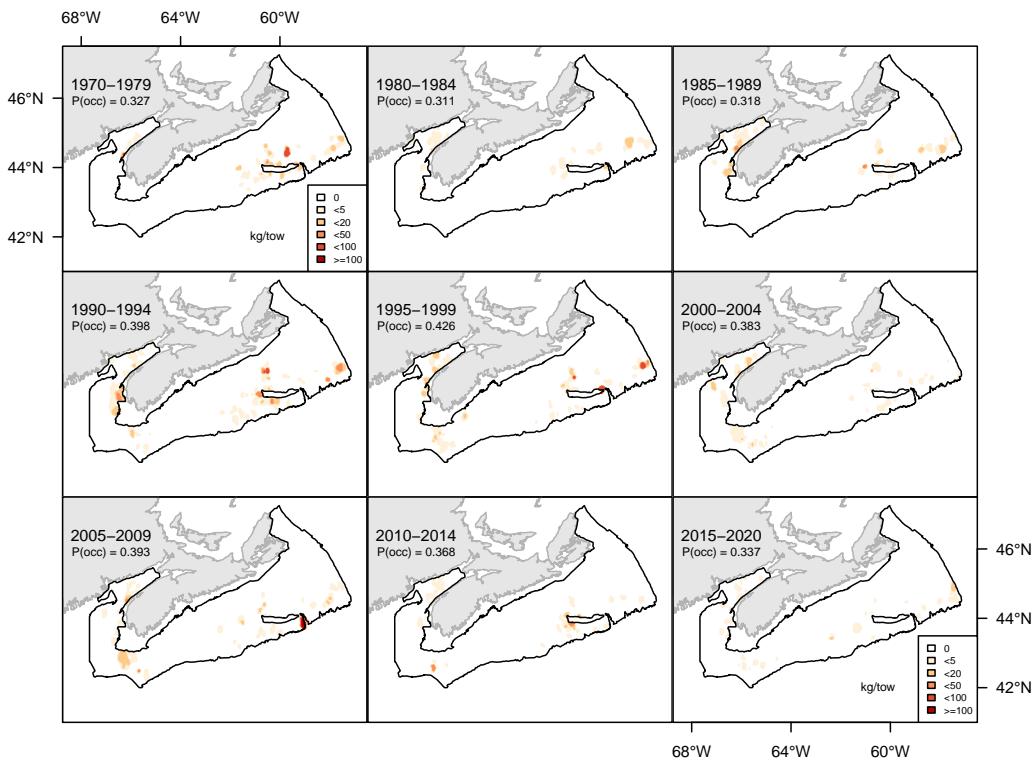


Figure 7.15A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longhorn sculpin.

835

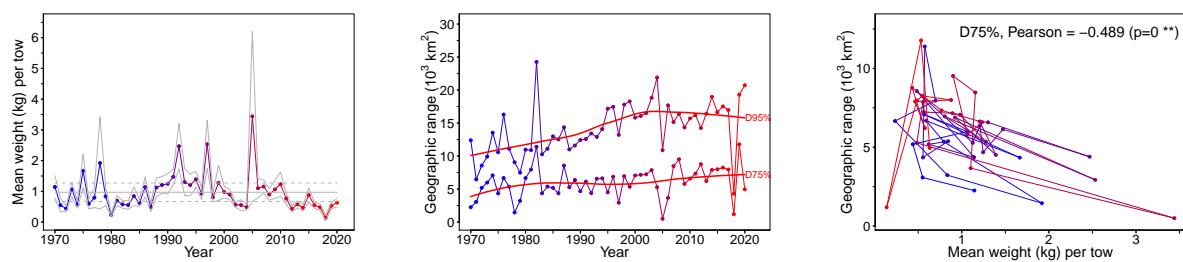


Figure 7.15B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longhorn sculpin.

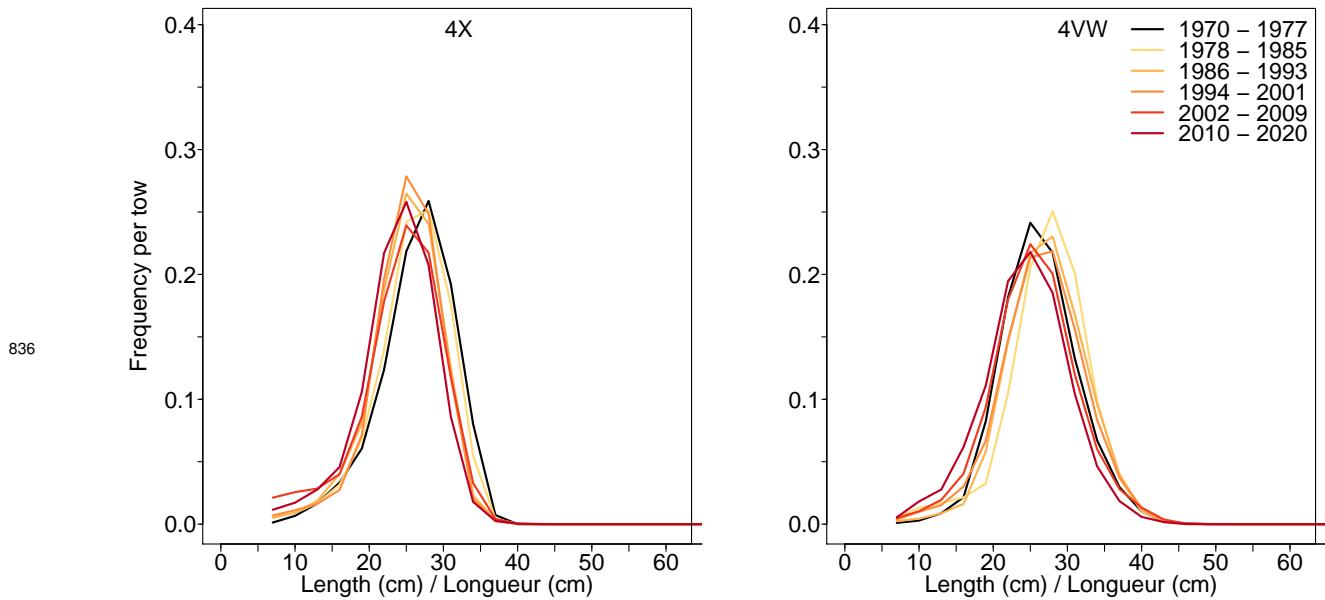


Figure 7.15C. Length frequency distribution in NAFO units 4X and 4VW for Longhorn sculpin.

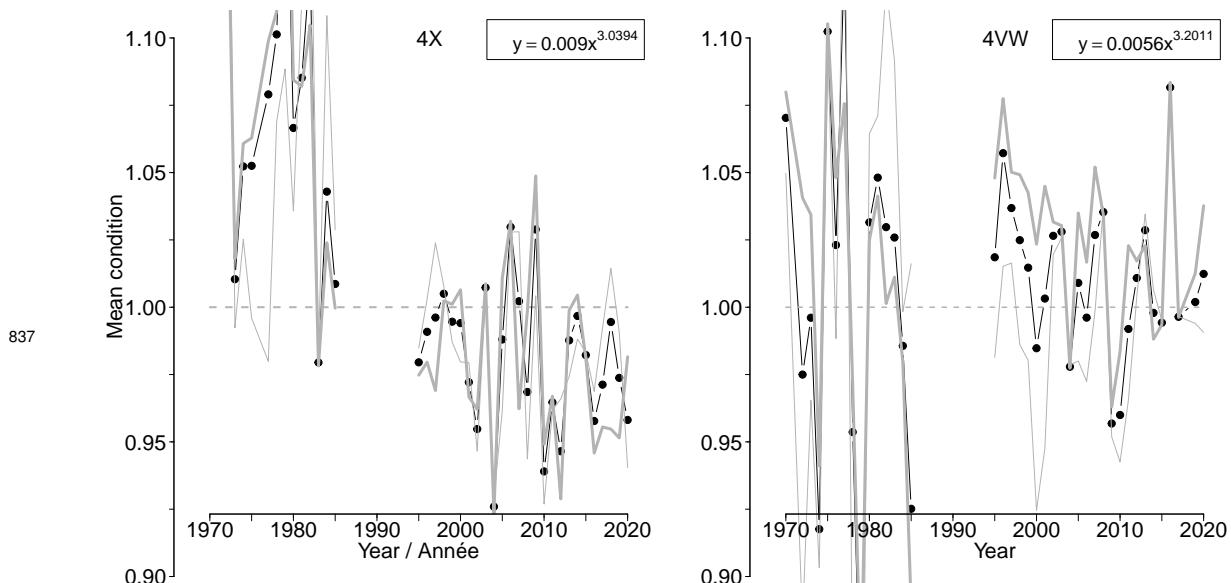
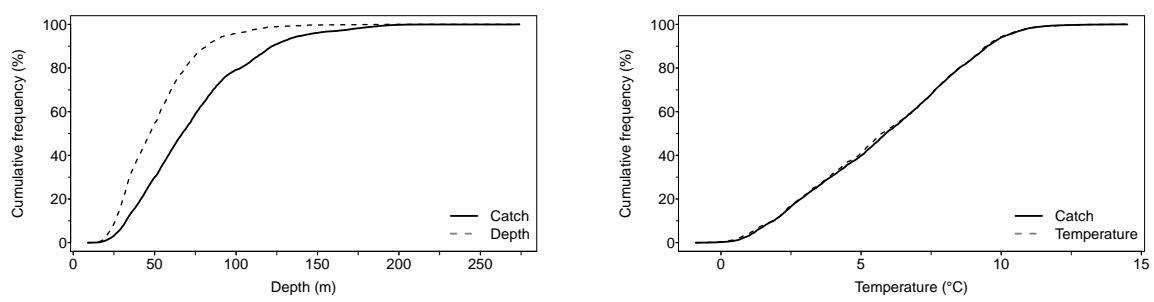
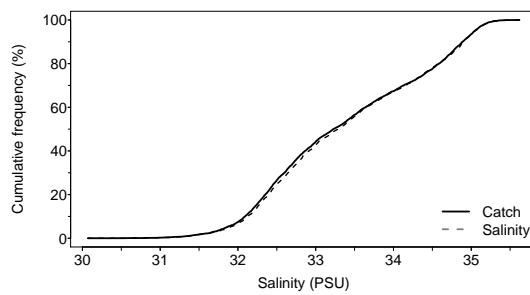


Figure 7.15D. Average fish condition in NAFO units 4X and 4VW for Longhorn sculpin.



838



Freq	Depth	Temp	Sal
F5	23	1.2	31.00
F25	33	3.3	32.51
F50	48	5.8	33.29
F75	64	8.1	34.38
F95	96	10.0	35.05

Figure 7.15E. Catch distribution by depth, temperature and salinity of Longhorn sculpin.

839

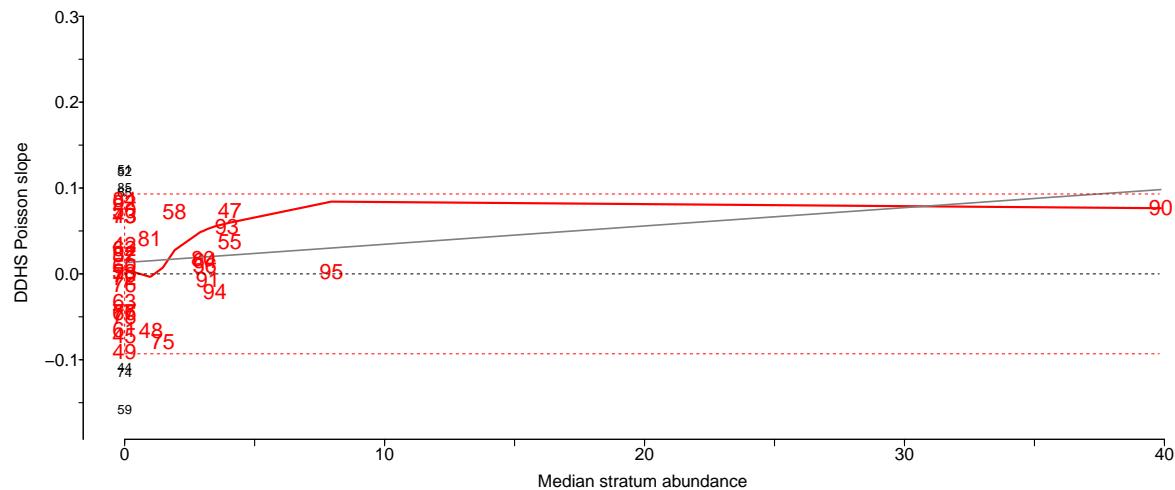


Figure 7.15F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Longhorn sculpin.

840

7.16 Moustache sculpin (Faux-trigle armé) - species code 304 (category LF)

841

Scientific name: [Triglops murrayi](#)

842

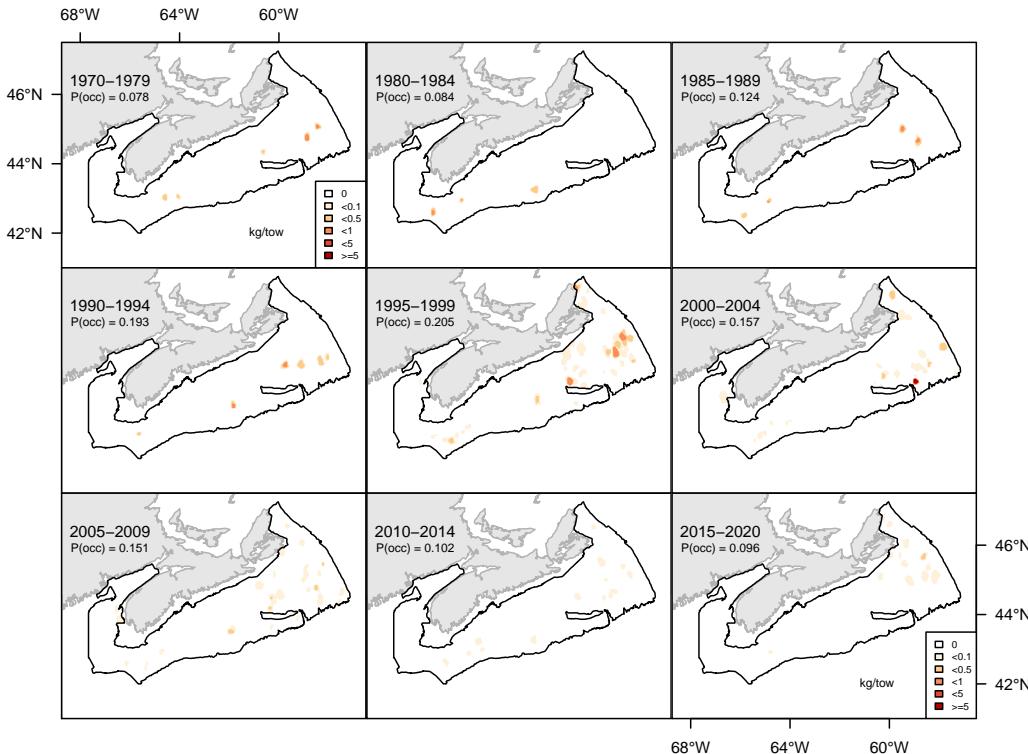


Figure 7.16A. Inverse distance weighted distribution of catch biomass (kg/tow) for Moustache sculpin.

843

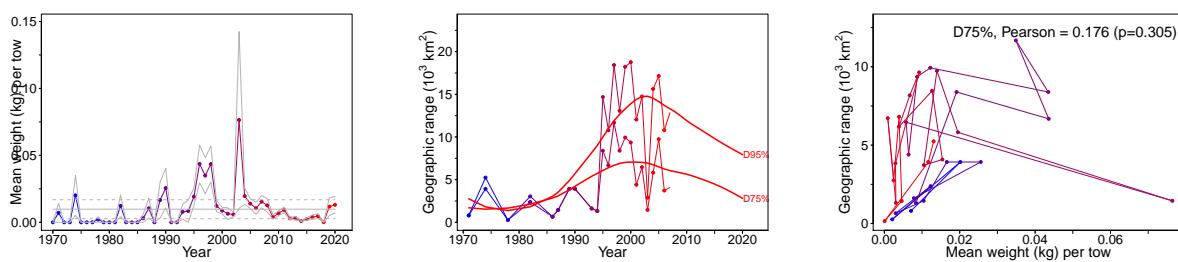


Figure 7.16B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Moustache sculpin.

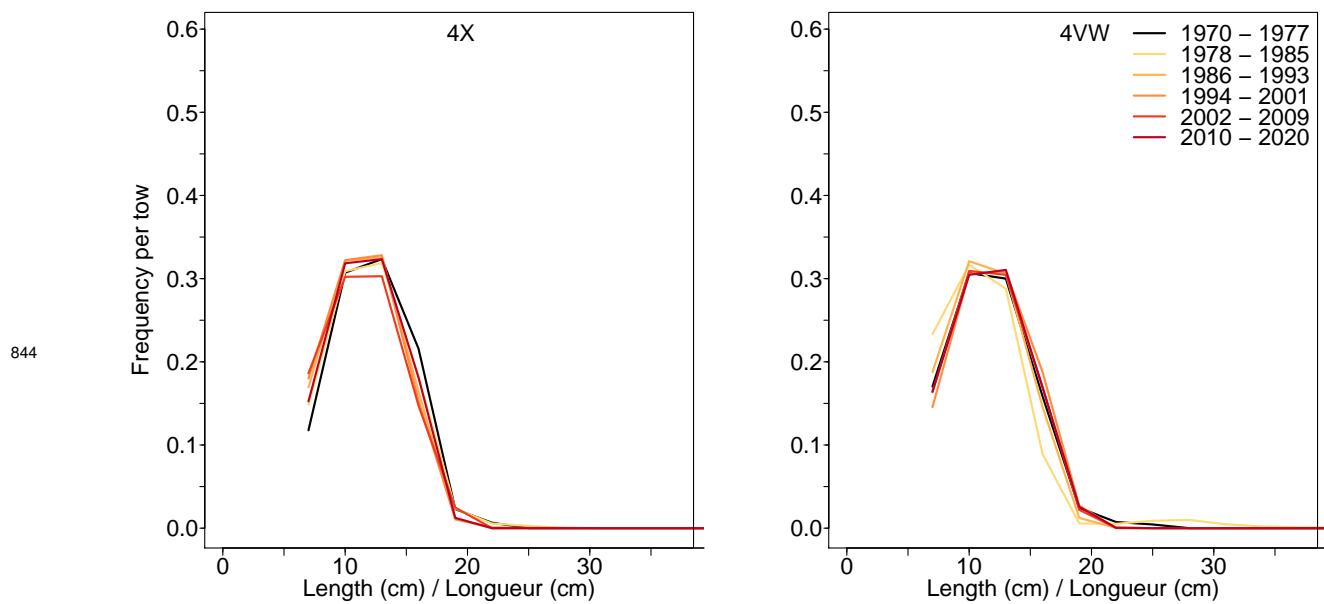


Figure 7.16C. Length frequency distribution in NAFO units 4X and 4VW for Moustache sculpin.

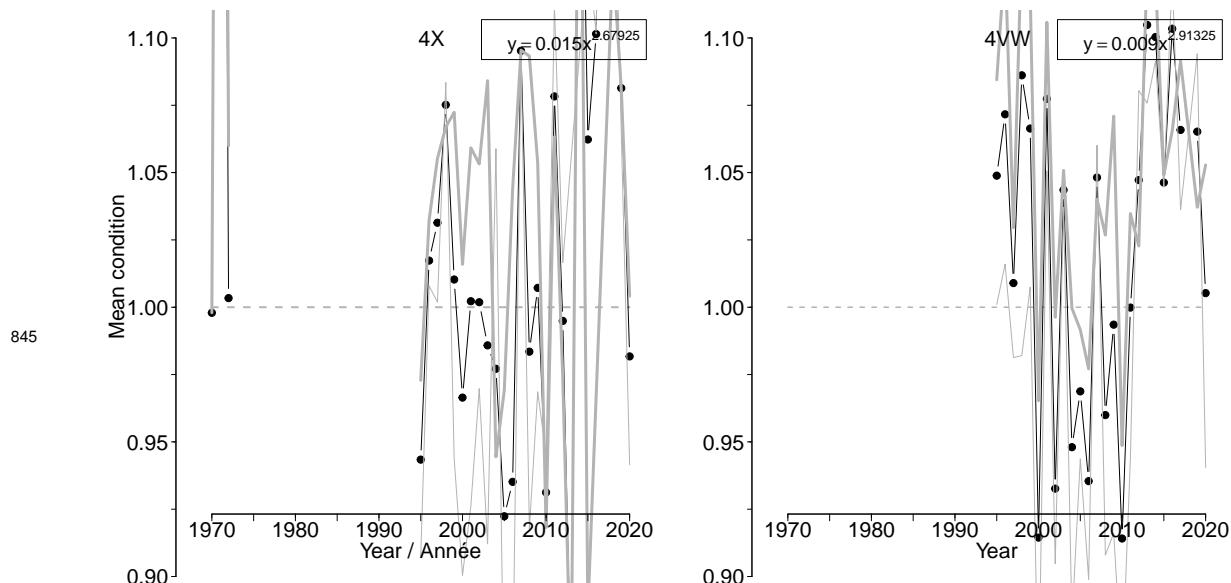
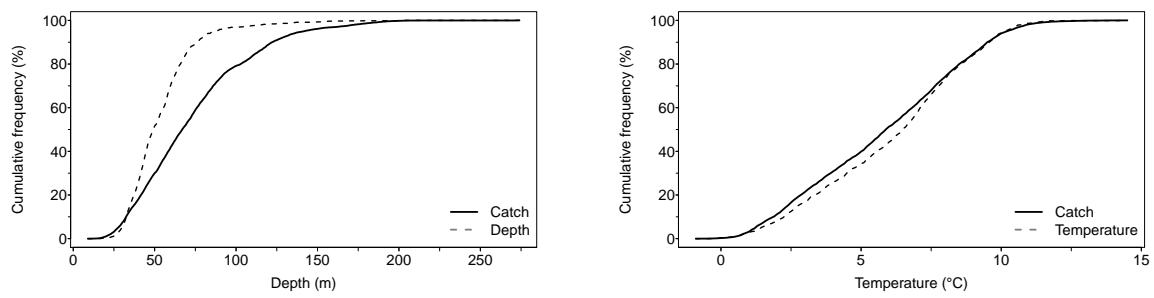
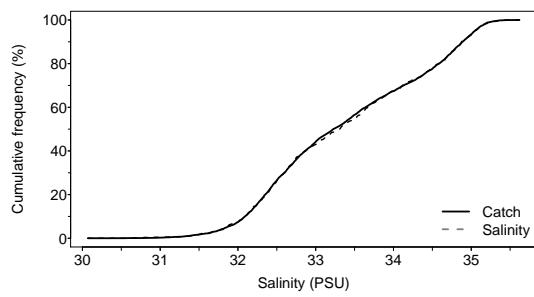


Figure 7.16D. Average fish condition in NAFO units 4X and 4VW for Moustache sculpin.



846



Freq	Depth	Temp	Sal
F5	30	1.5	31.00
F25	40	4.0	32.48
F50	50	6.5	33.31
F75	63	8.2	34.39
F95	88	10.0	35.06

Figure 7.16E. Catch distribution by depth, temperature and salinity of Moustache sculpin.

847

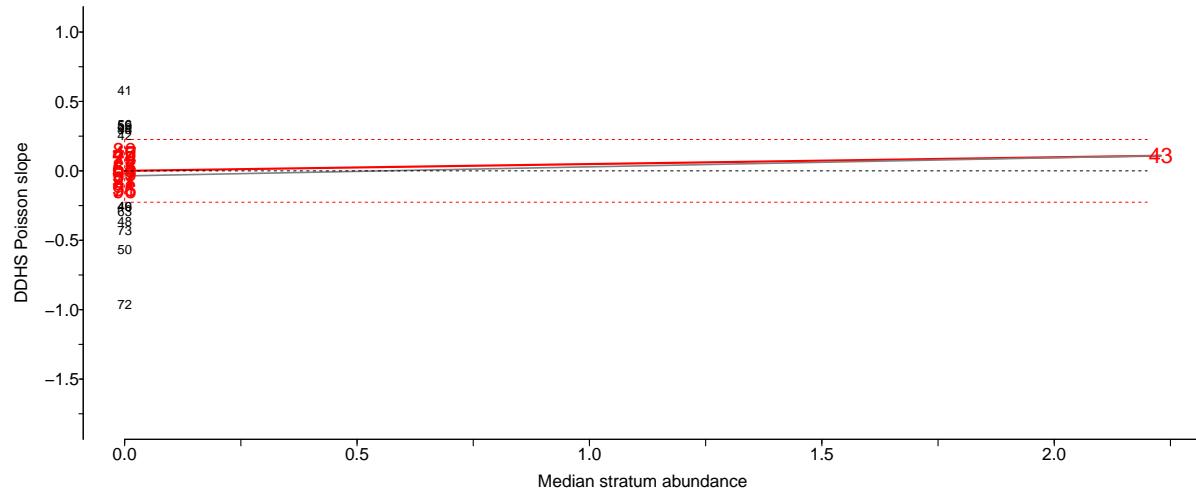


Figure 7.16F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Moustache sculpin.

848

7.17 Sea raven (Hémithriptère atlantique) - species code 320 (category LF)

849

Scientific name: [Hemitripterus americanus](#)

850

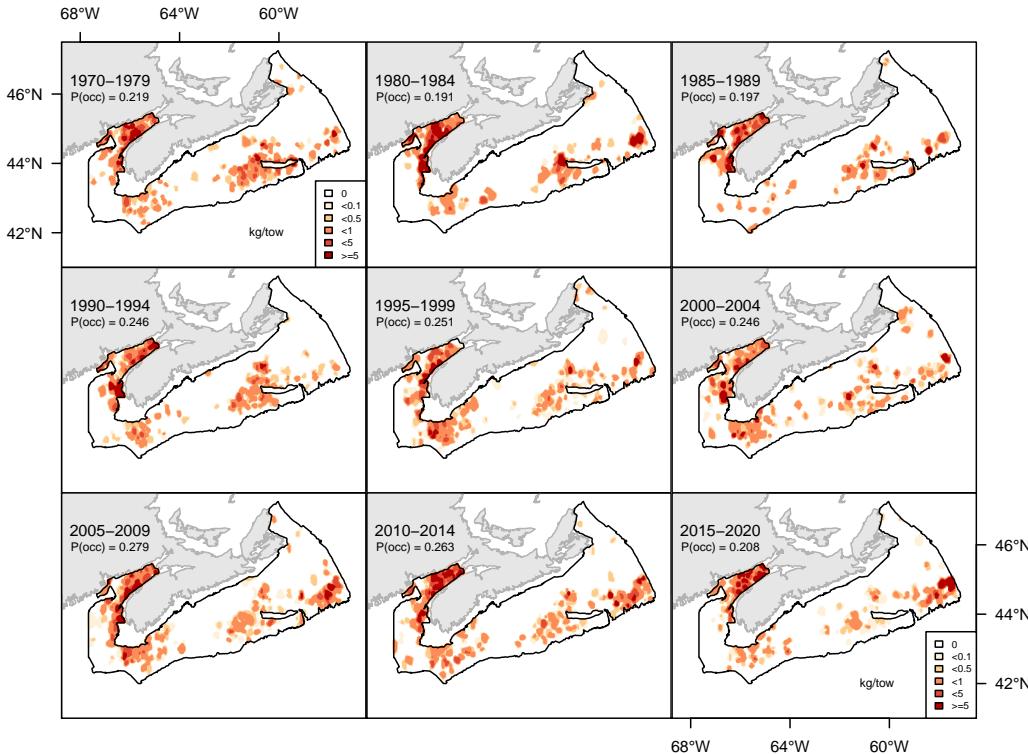


Figure 7.17A. Inverse distance weighted distribution of catch biomass (kg/tow) for Sea raven.

851

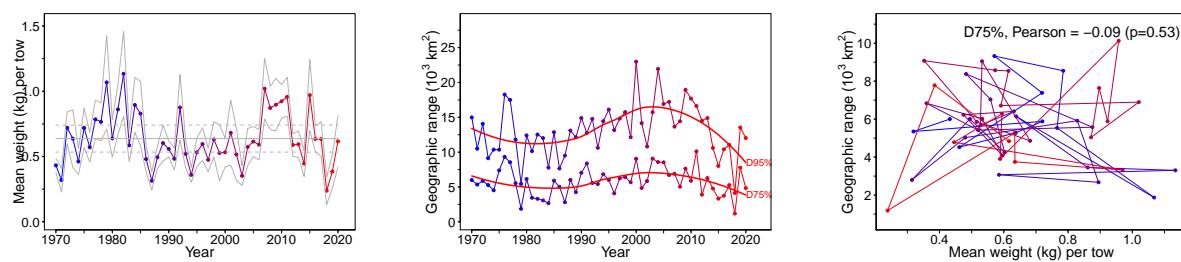


Figure 7.17B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sea raven.

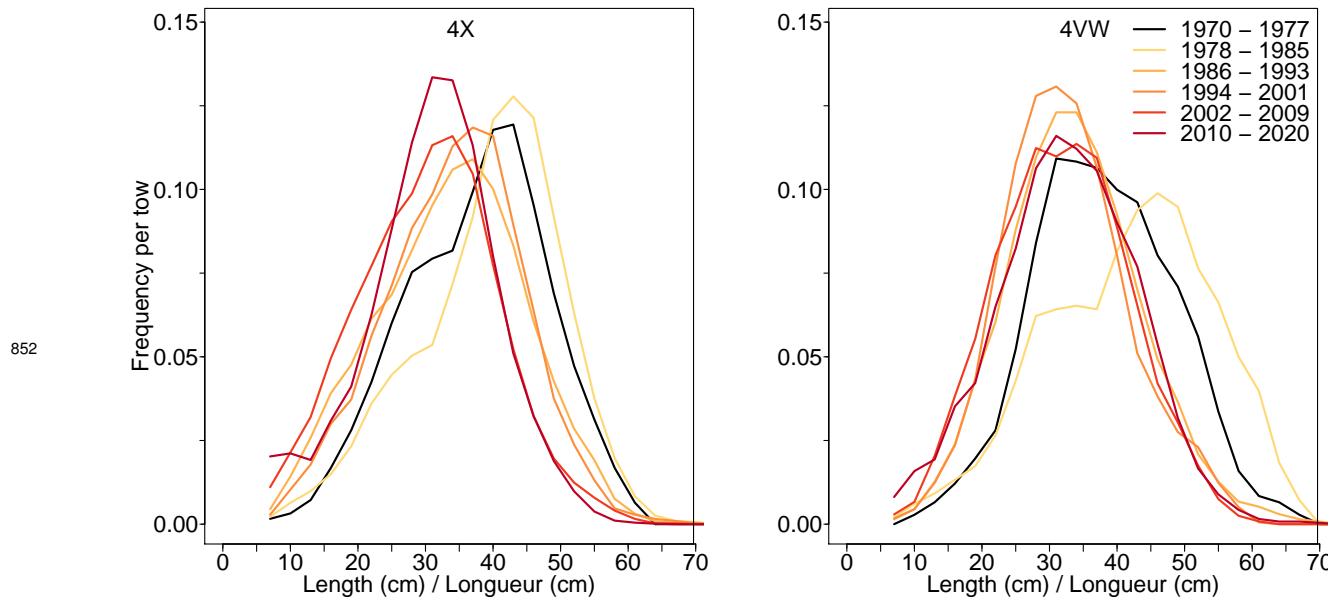


Figure 7.17C. Length frequency distribution in NAFO units 4X and 4VW for Sea raven.

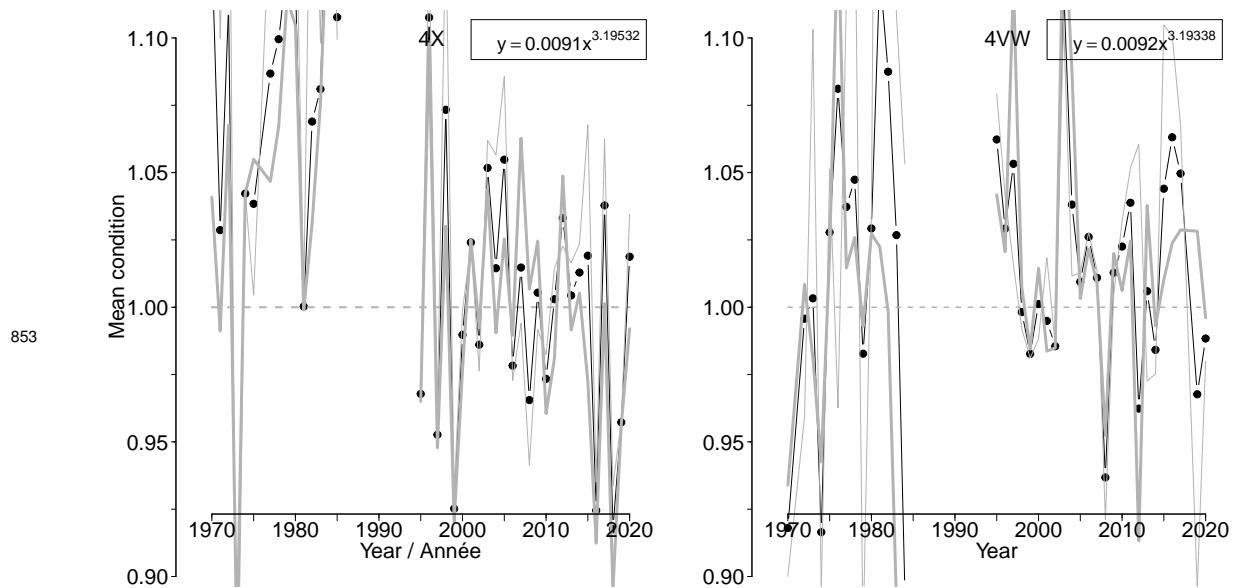
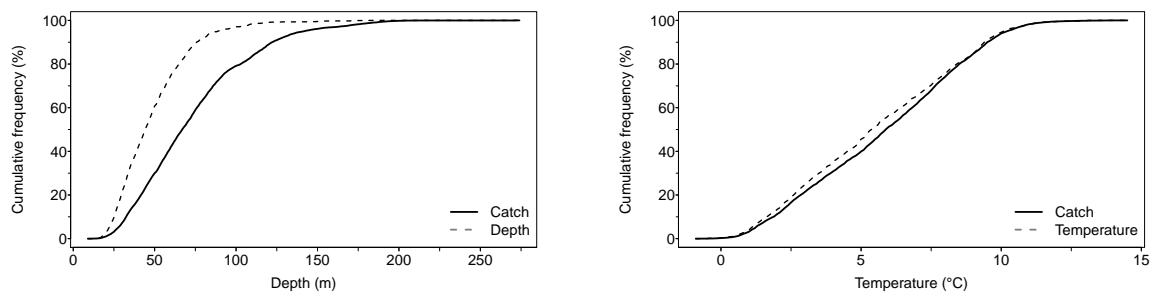
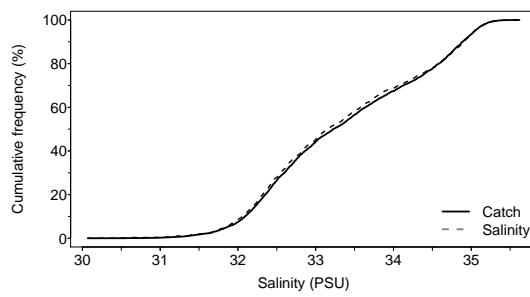


Figure 7.17D. Average fish condition in NAFO units 4X and 4VW for Sea raven.

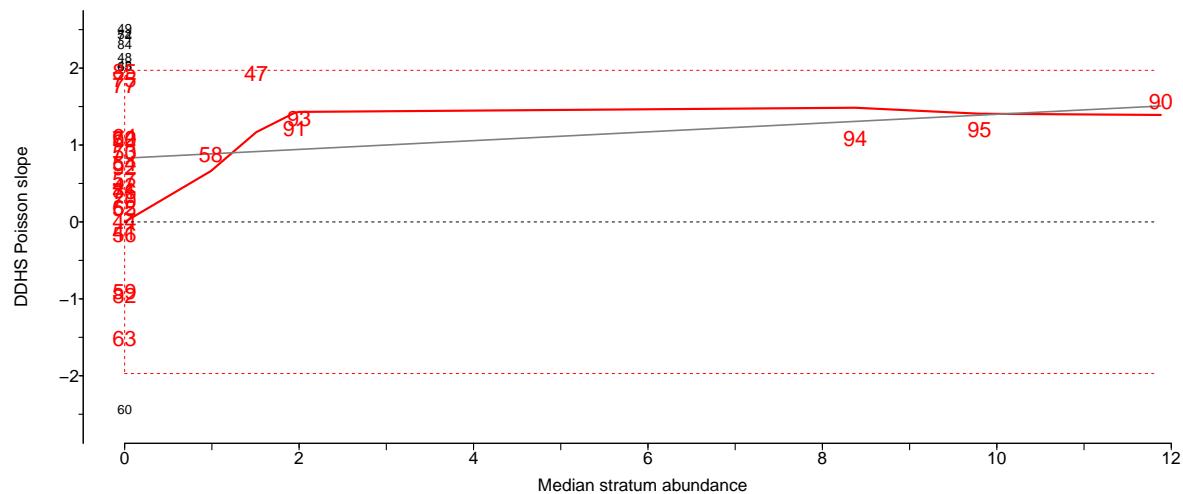


854



Freq	Depth	Temp	Sal
F5	22	1.1	31.00
F25	32	3.1	32.43
F50	45	5.4	33.15
F75	61	8.0	34.35
F95	89	10.0	35.05

Figure 7.17E. Catch distribution by depth, temperature and salinity of Sea raven.



855

Figure 7.17F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Sea raven.

856 **7.18 Alligatorfish (Poisson-alligator atlantique) - species code 340 (category LF)**

857 Scientific name: [Aspidophoroides monopterygius](#)

858

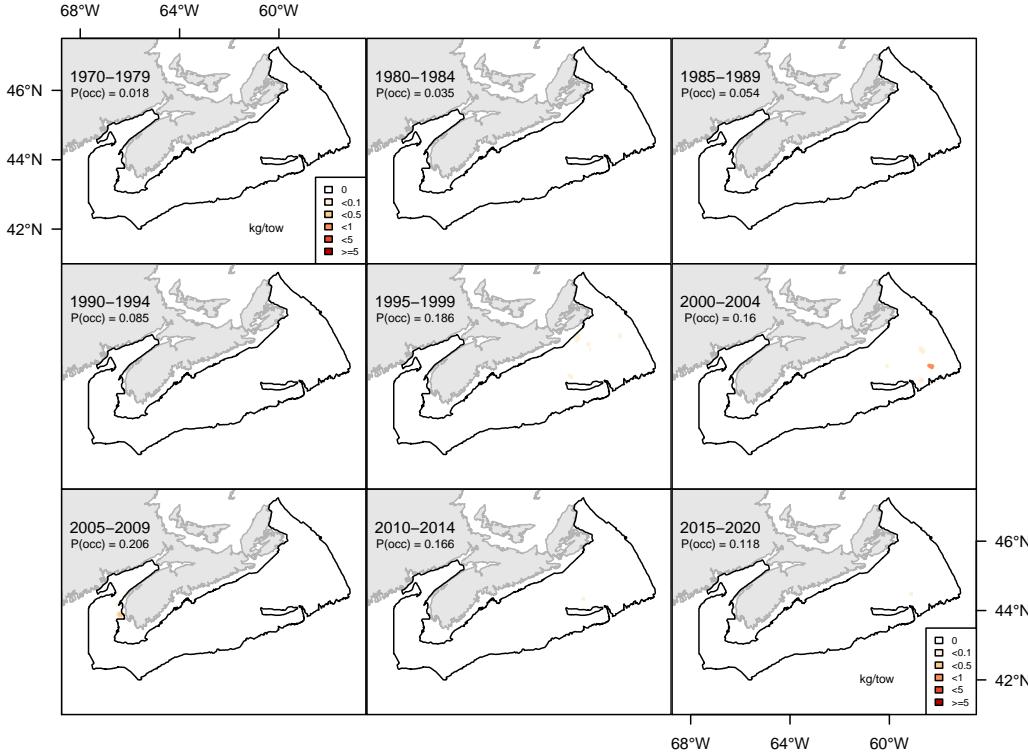


Figure 7.18A. Inverse distance weighted distribution of catch biomass (kg/tow) for Alligatorfish.

859

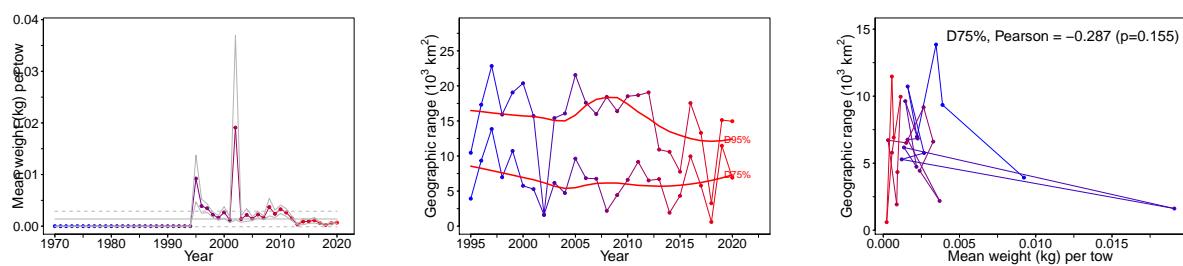


Figure 7.18B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alligatorfish.

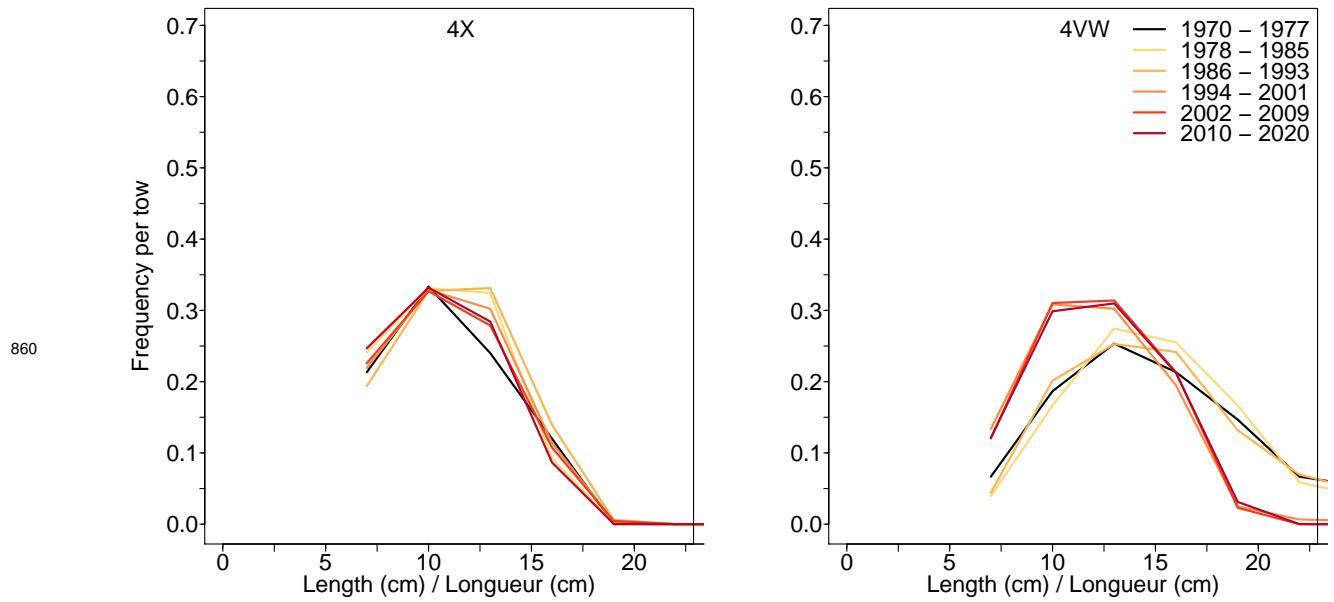


Figure 7.18C. Length frequency distribution in NAFO units 4X and 4VW for Alligatorfish.

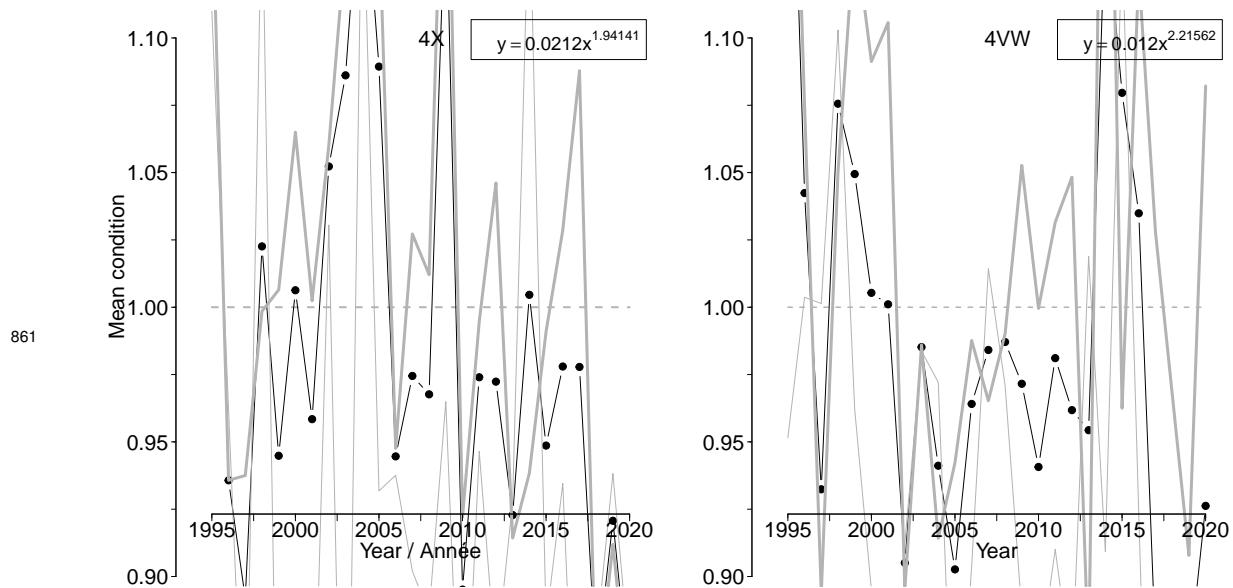
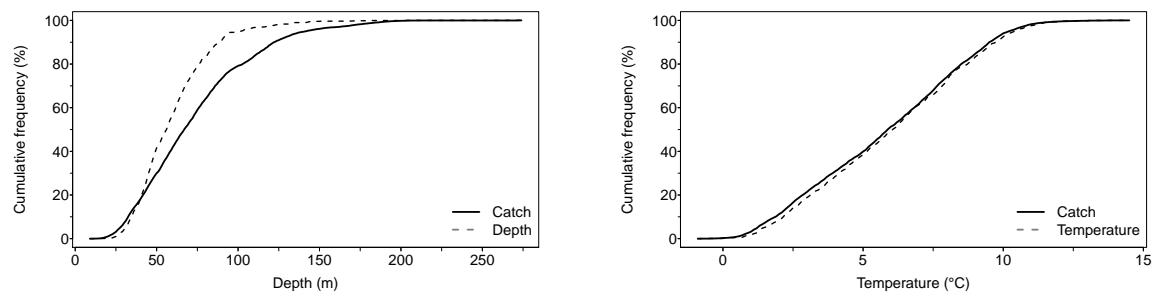
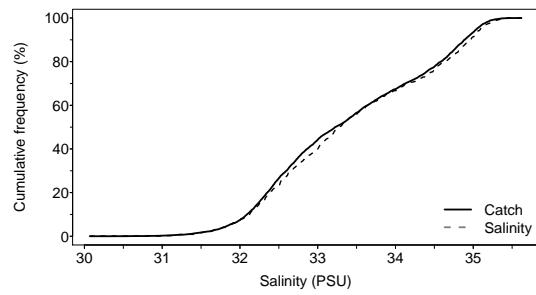


Figure 7.18D. Average fish condition in NAFO units 4X and 4VW for Alligatorfish.



862



Freq	Depth	Temp	Sal
F5	32	1.5	31.00
F25	44	3.7	32.53
F50	57	6.1	33.28
F75	72	8.2	34.45
F95	102	10.0	35.10

Figure 7.18E. Catch distribution by depth, temperature and salinity of Alligatorfish.

863

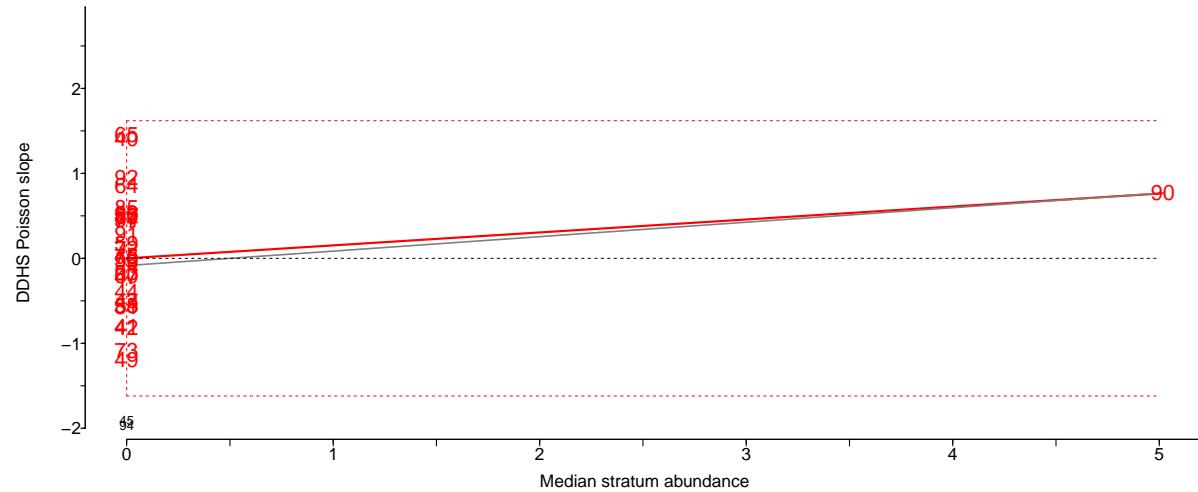


Figure 7.18F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Alligatorfish.

864

7.19 Monkfish (Baudroie d'Amérique) - species code 400 (category LF)

865

Scientific name: [Lophius americanus](#)

866

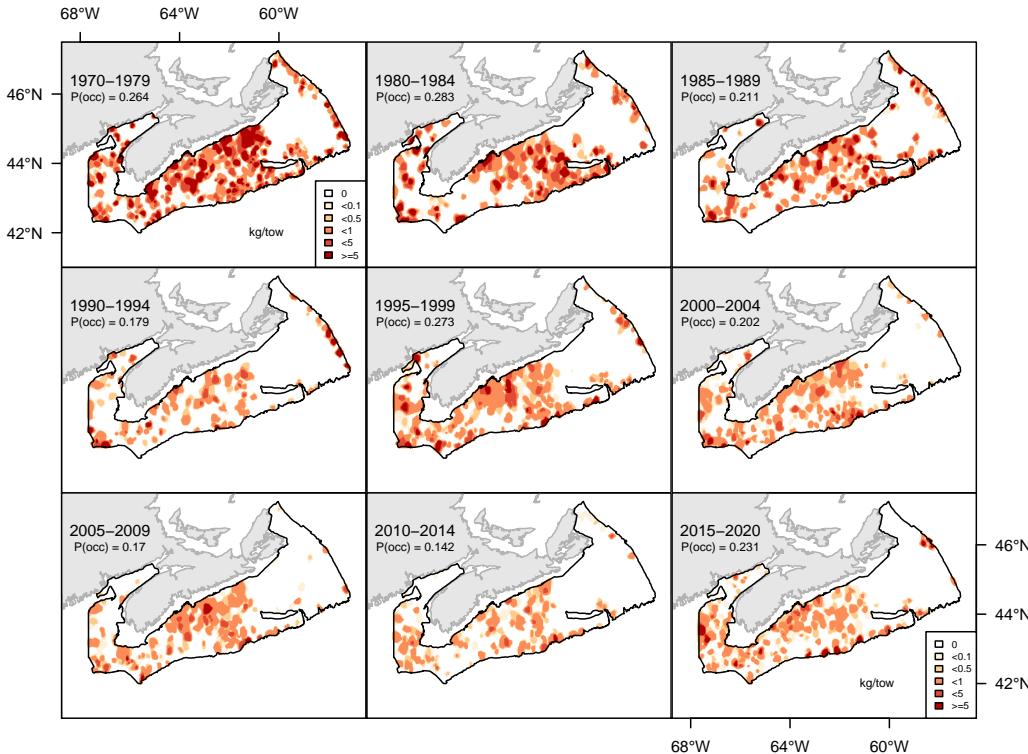


Figure 7.19A. Inverse distance weighted distribution of catch biomass (kg/tow) for Monkfish.

867

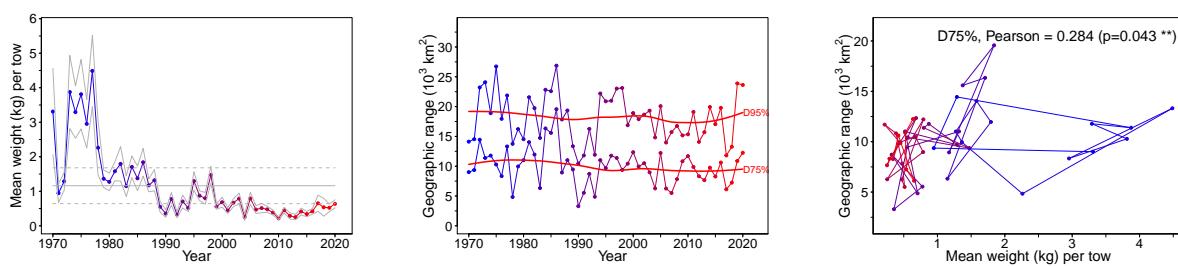


Figure 7.19B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Monkfish.

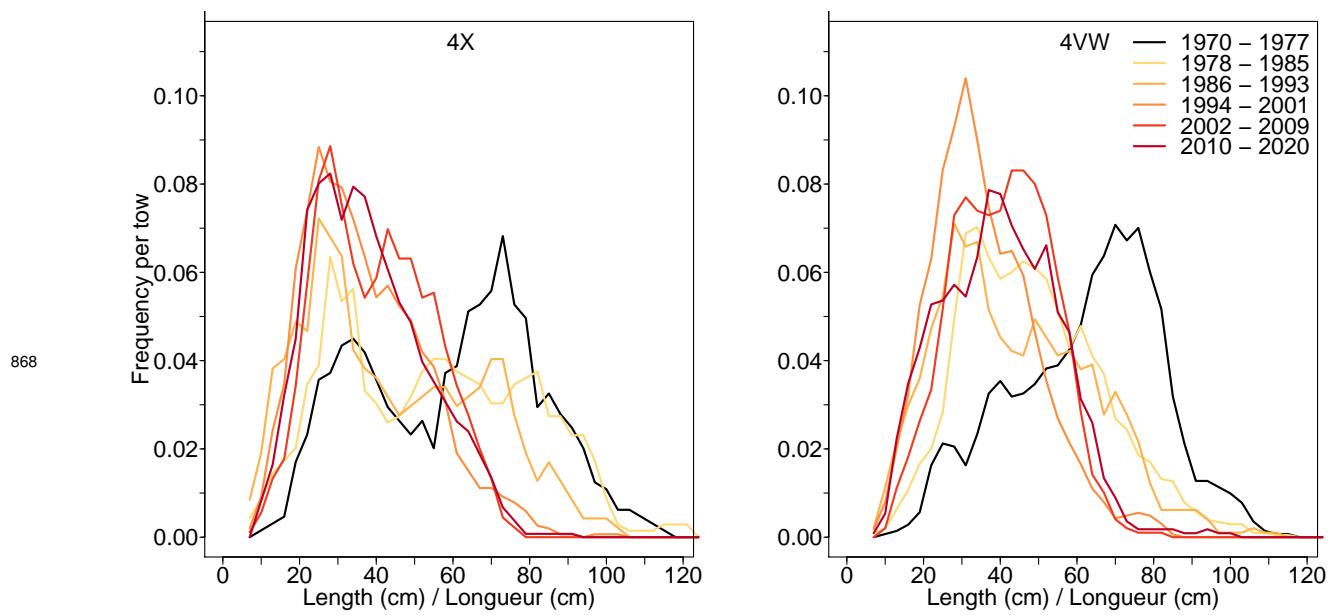


Figure 7.19C. Length frequency distribution in NAFO units 4X and 4VW for Monkfish.

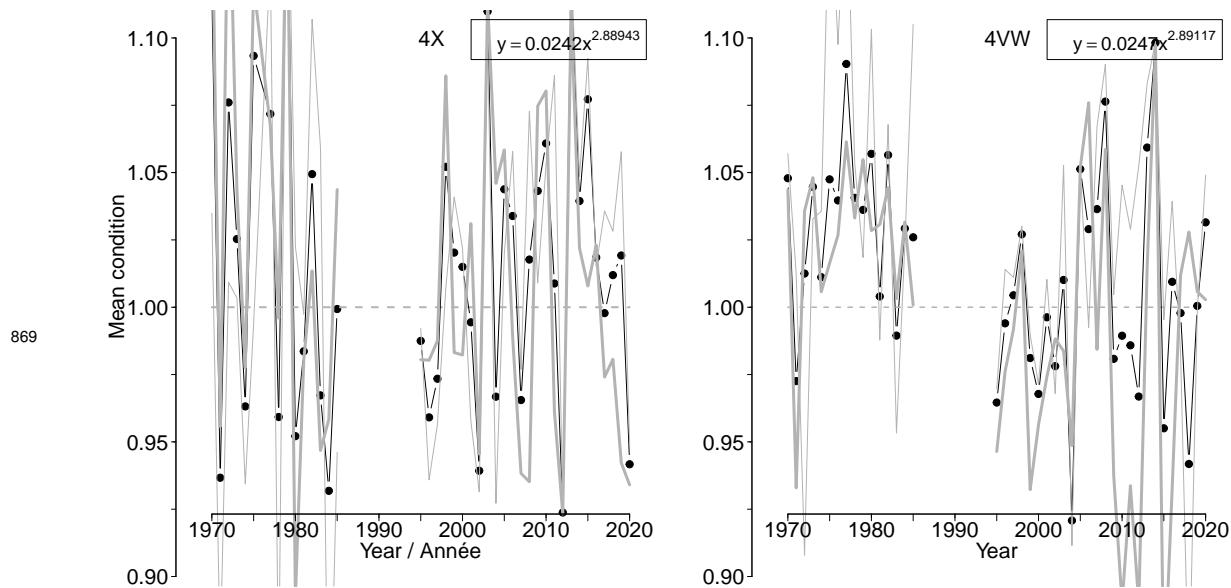
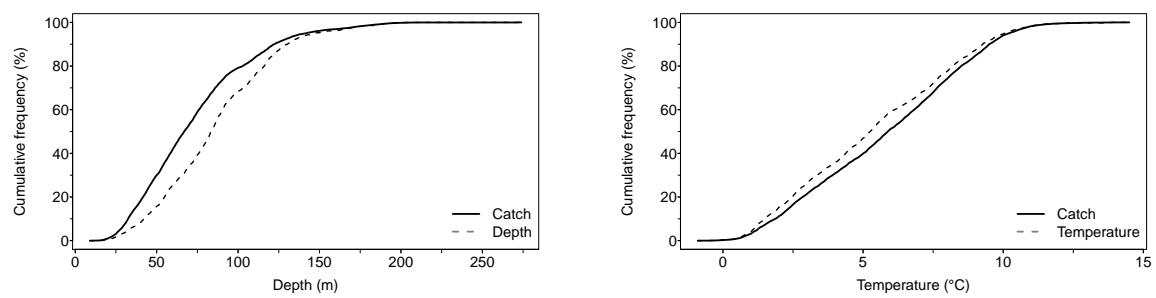
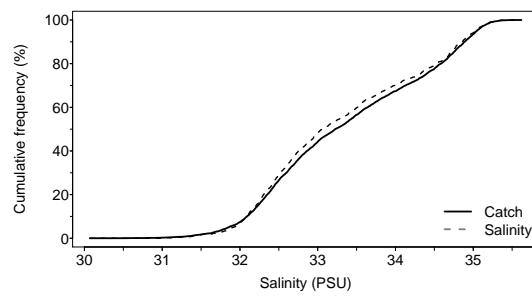


Figure 7.19D. Average fish condition in NAFO units 4X and 4VW for Monkfish.



870



Freq	Depth	Temp	Sal
F5	33	1.1	31.00
F25	60	2.9	32.43
F50	84	5.3	33.07
F75	110	7.8	34.31
F95	148	10.0	35.03

Figure 7.19E. Catch distribution by depth, temperature and salinity of Monkfish.

871

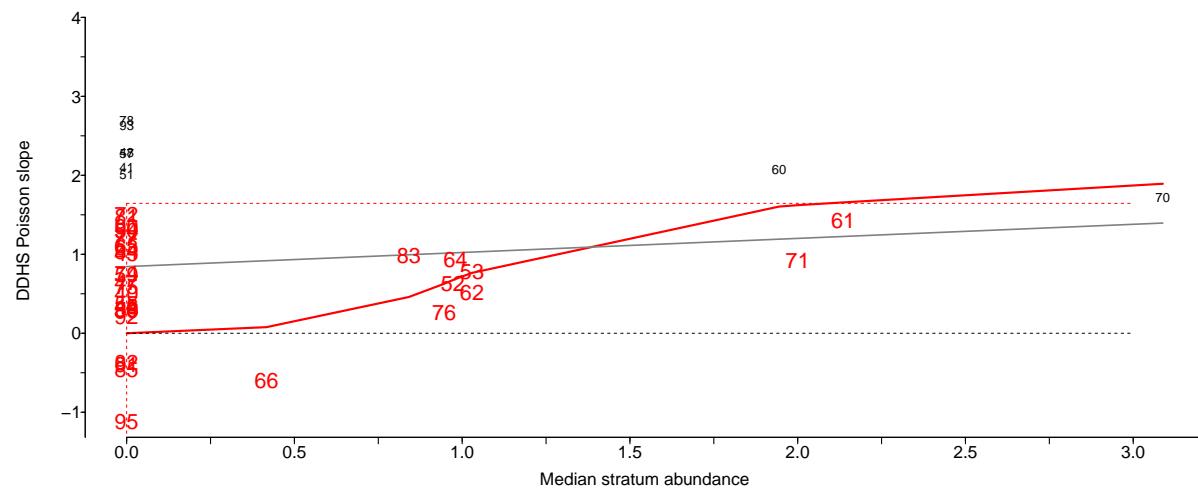


Figure 7.19F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Monkfish.

872

7.20 Ocean pout (Loquette d'Amérique) - species code 640 (category LF)

873

Scientific name: [Zoarces americanus](#)

874

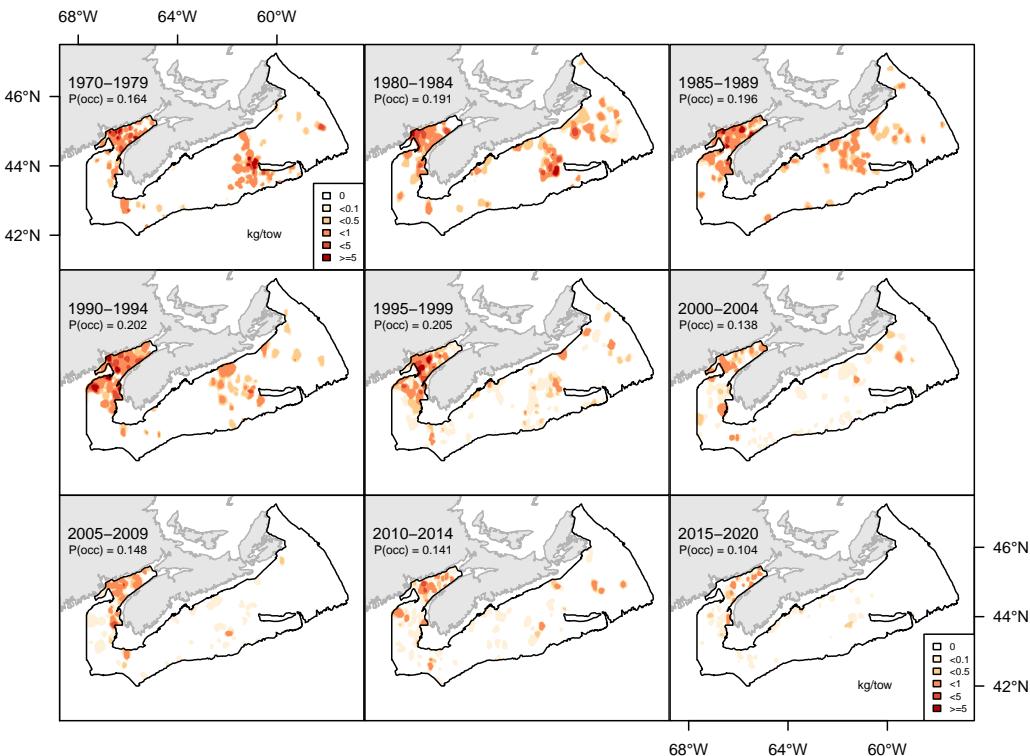


Figure 7.20A. Inverse distance weighted distribution of catch biomass (kg/tow) for Ocean pout.

875

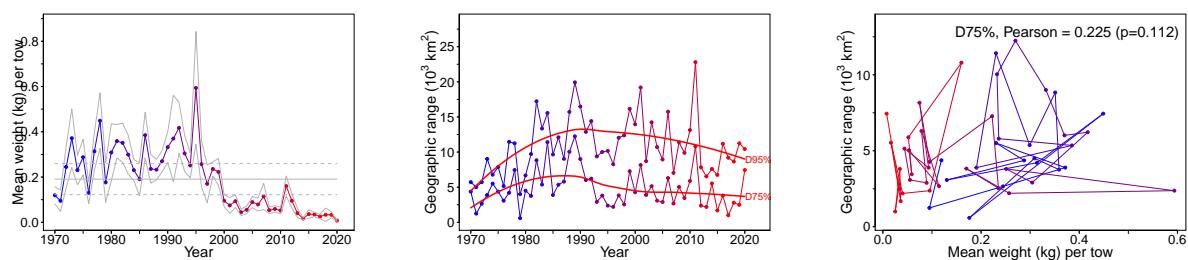


Figure 7.20B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Ocean pout.

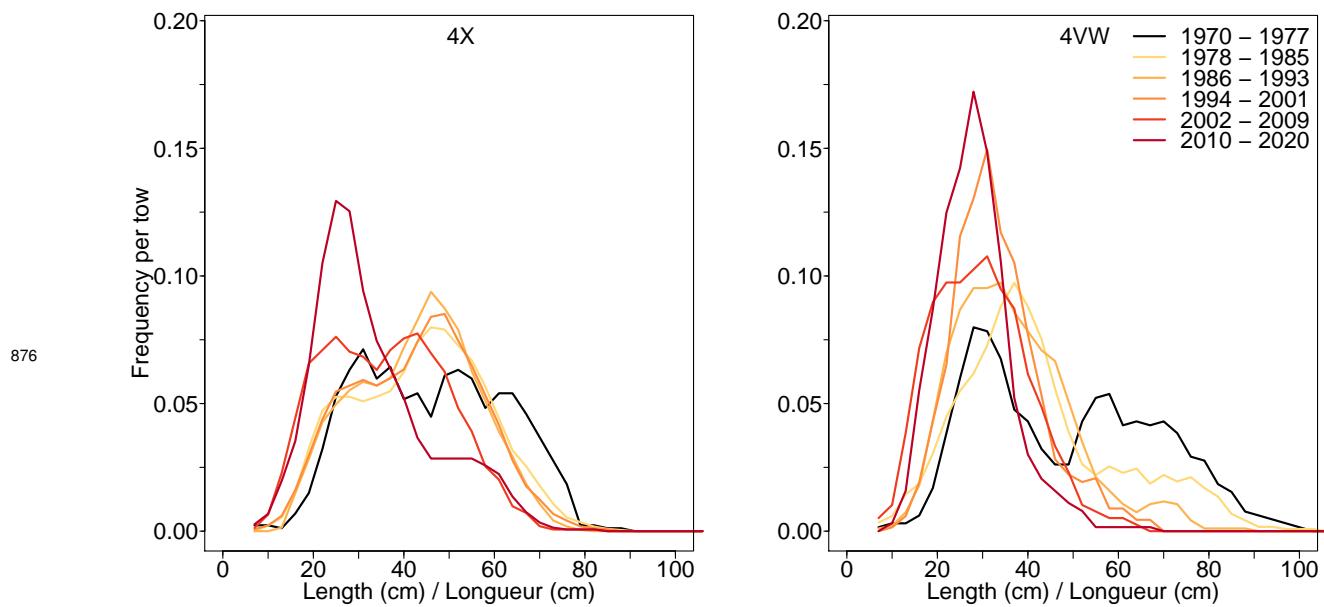


Figure 7.20C. Length frequency distribution in NAFO units 4X and 4VW for Ocean pout.

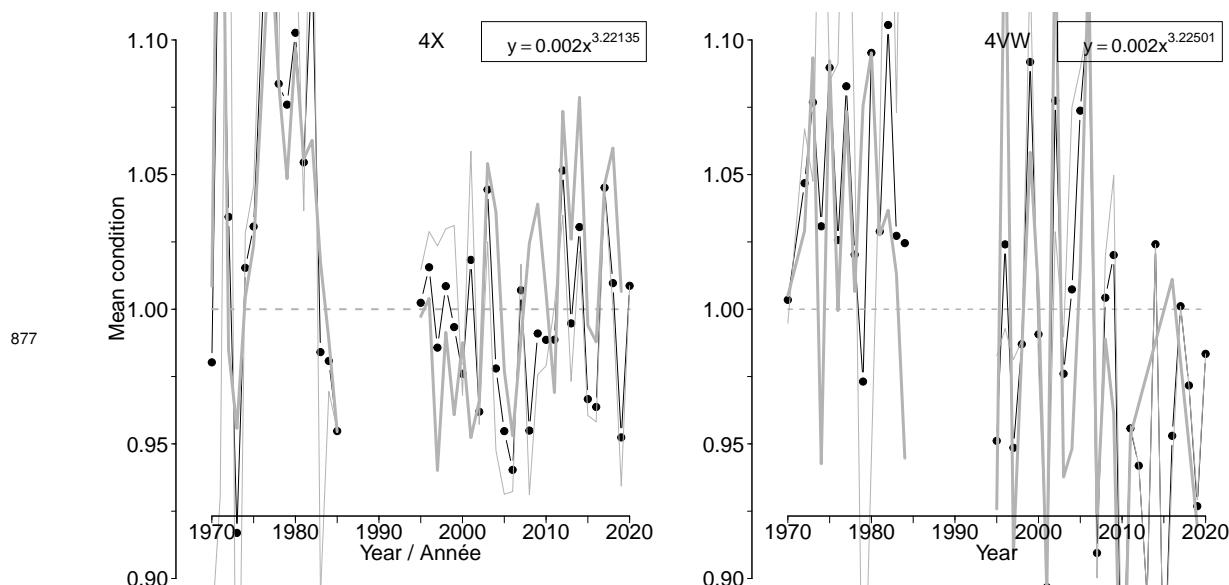
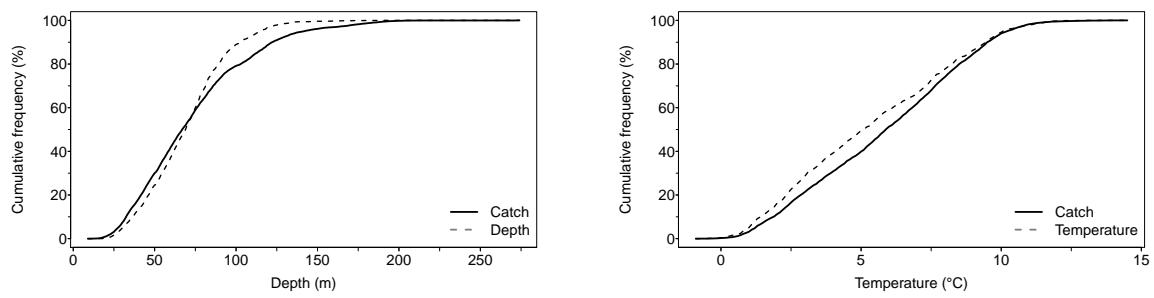
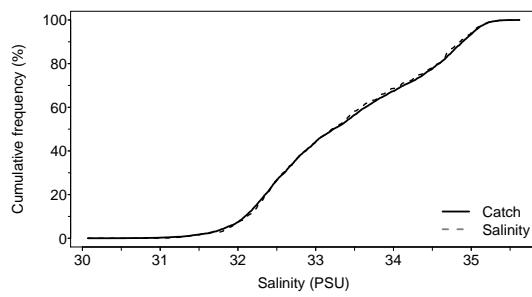


Figure 7.20D. Average fish condition in NAFO units 4X and 4VW for Ocean pout.



878



Freq	Depth	Temp	Sal
F5	31	1.0	31.00
F25	52	2.8	32.46
F50	69	5.1	33.22
F75	85	7.7	34.34
F95	116	10.0	35.03

Figure 7.20E. Catch distribution by depth, temperature and salinity of Ocean pout.

879

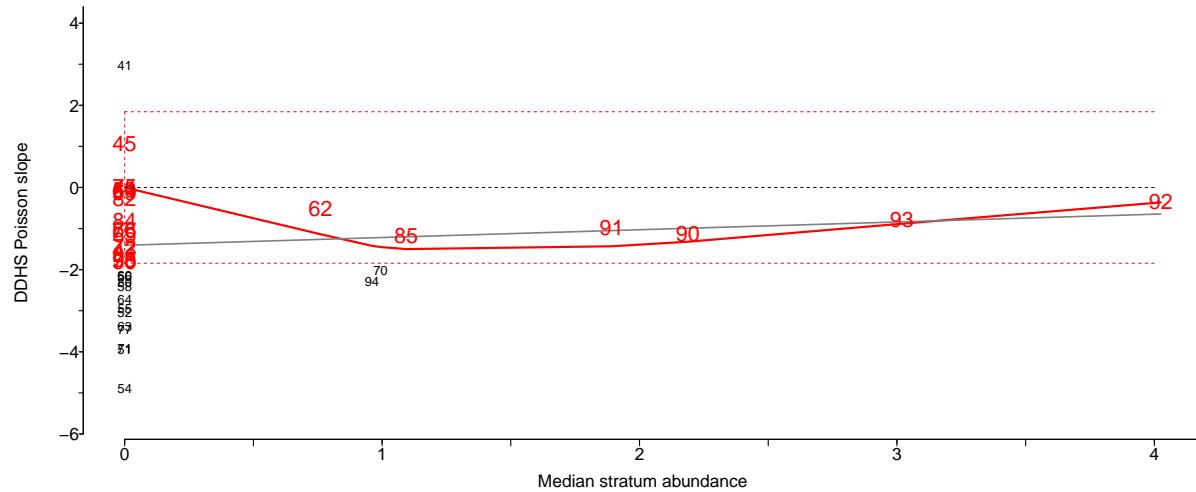


Figure 7.20F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Ocean pout.

880 **7.21 Thorny skate (Raie épineuse) - species code 201 (category LF)**

881 Scientific name: [Amblyraja radiata](#)

882

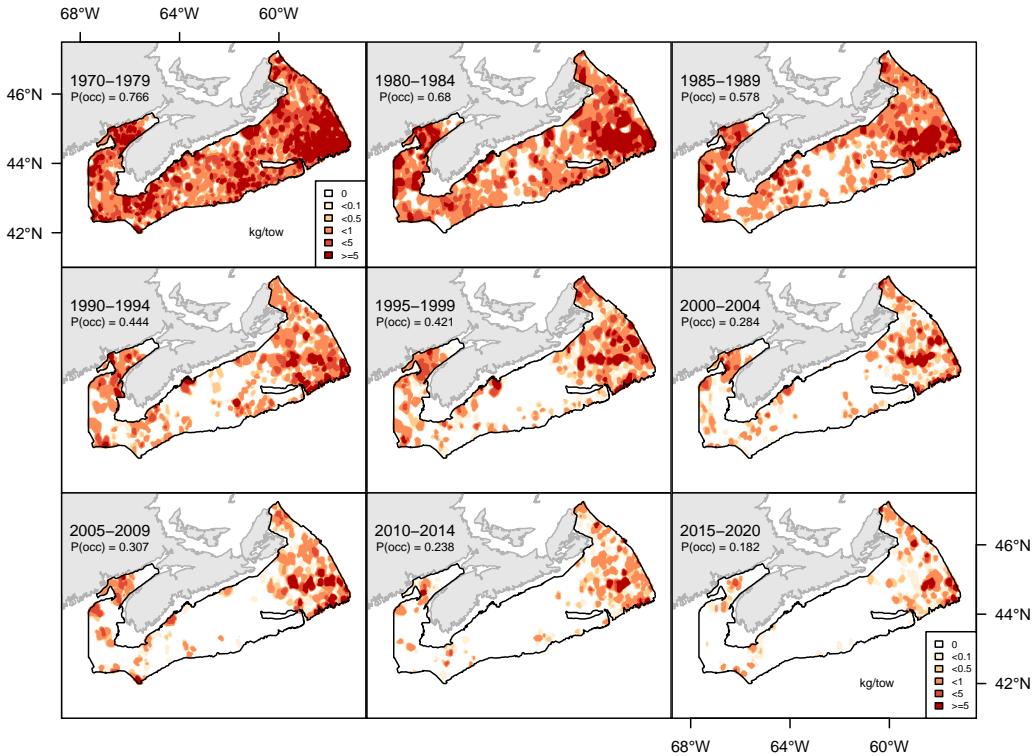


Figure 7.21A. Inverse distance weighted distribution of catch biomass (kg/tow) for Thorny skate.

883

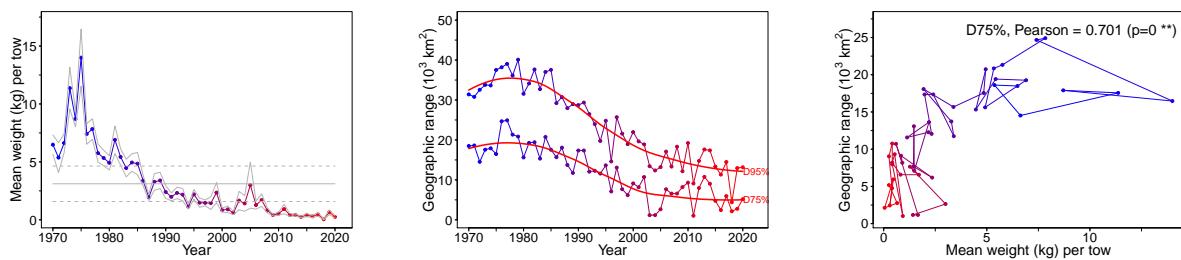


Figure 7.21B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Thorny skate.

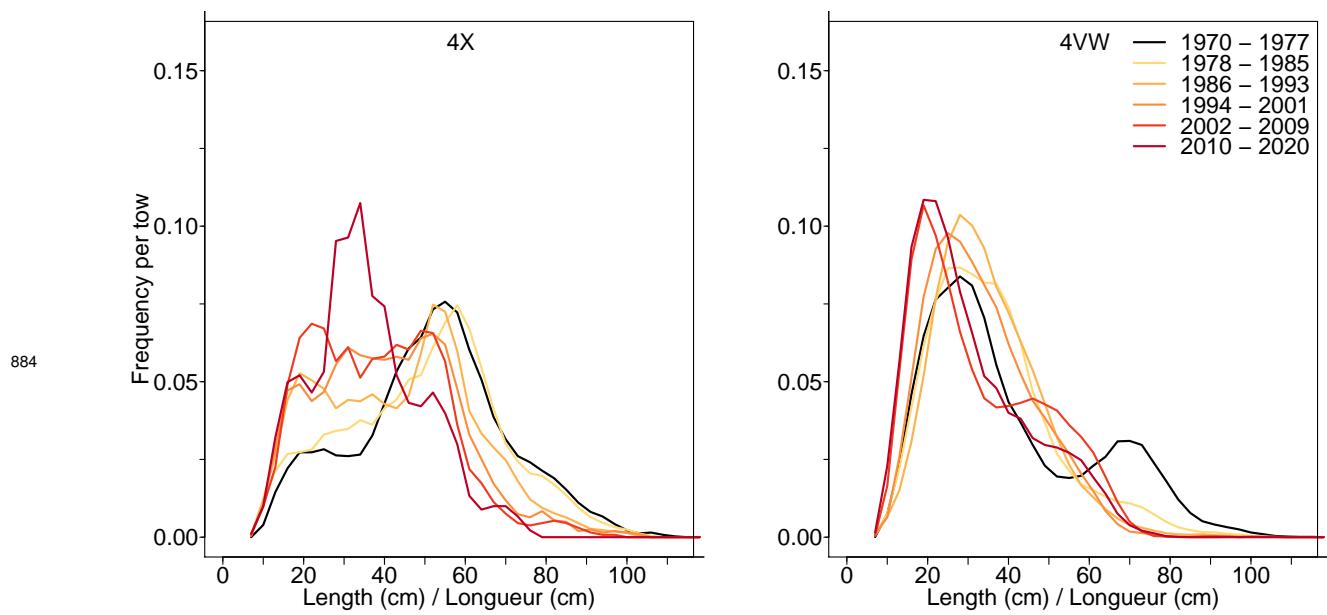


Figure 7.21C. Length frequency distribution in NAFO units 4X and 4VW for Thorny skate.

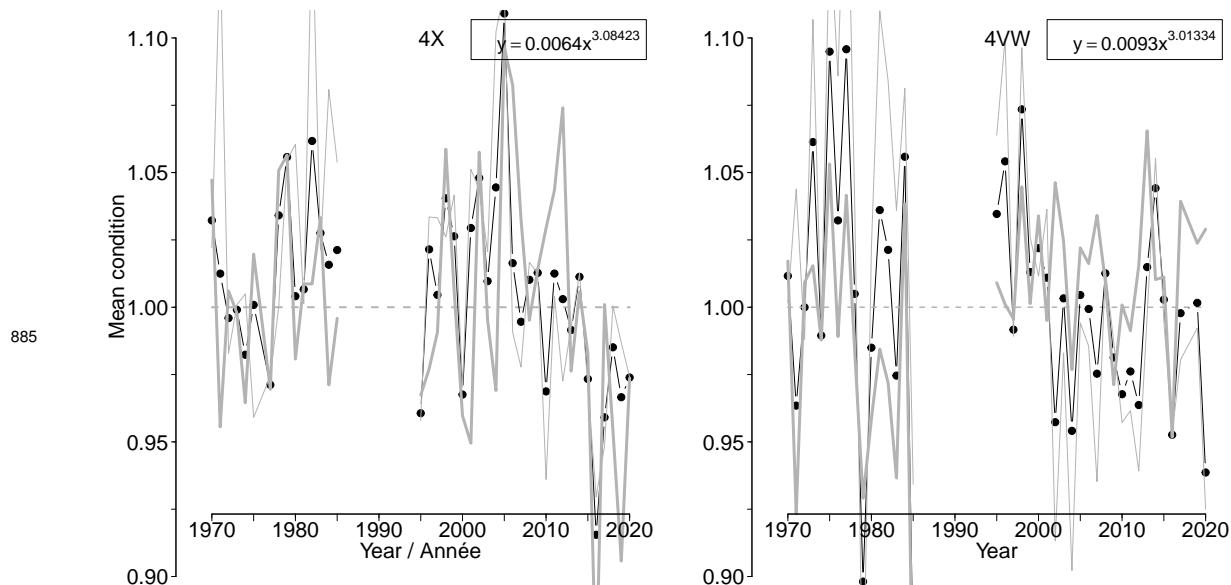
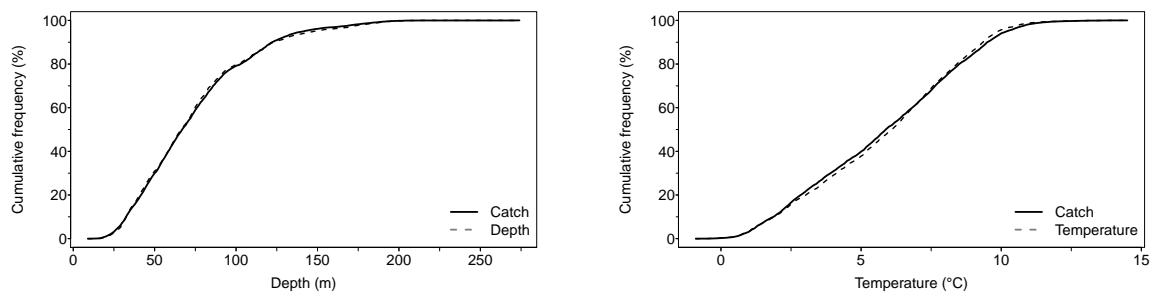
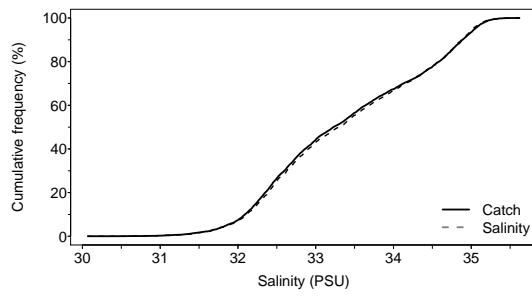


Figure 7.21D. Average fish condition in NAFO units 4X and 4VW for Thorny skate.

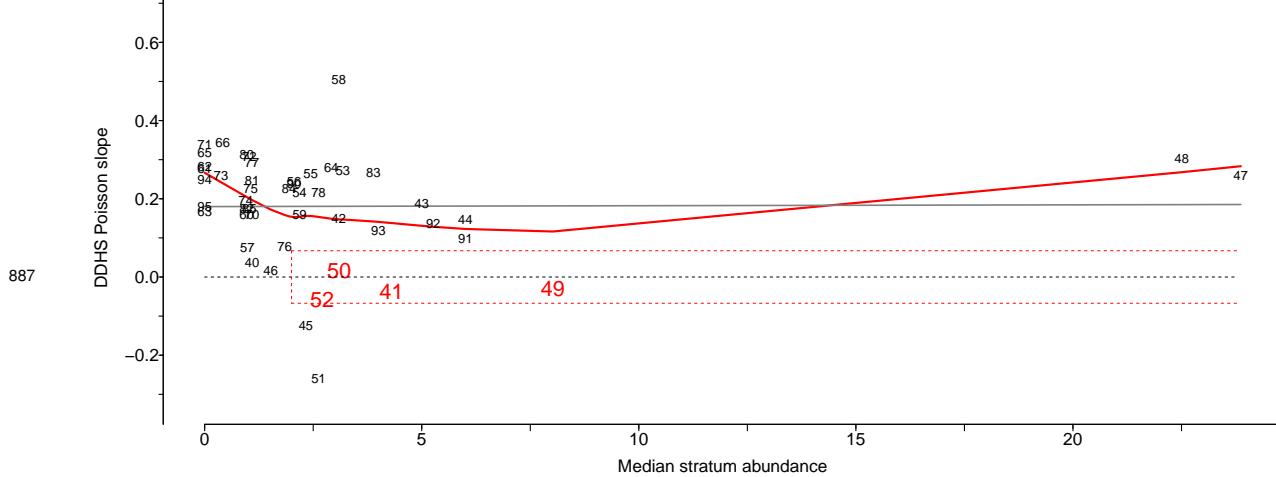


886



Freq	Depth	Temp	Sal
F5	29	1.3	31.00
F25	45	3.7	32.50
F50	67	6.2	33.30
F75	91	8.1	34.40
F95	148	9.9	35.03

Figure 7.21E. Catch distribution by depth, temperature and salinity of Thorny skate.



887

Figure 7.21F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Thorny skate.

888

7.22 Smooth skate (Raie lisse) - species code 202 (category LF)

889

Scientific name: [Malacoraja senta](#)

890

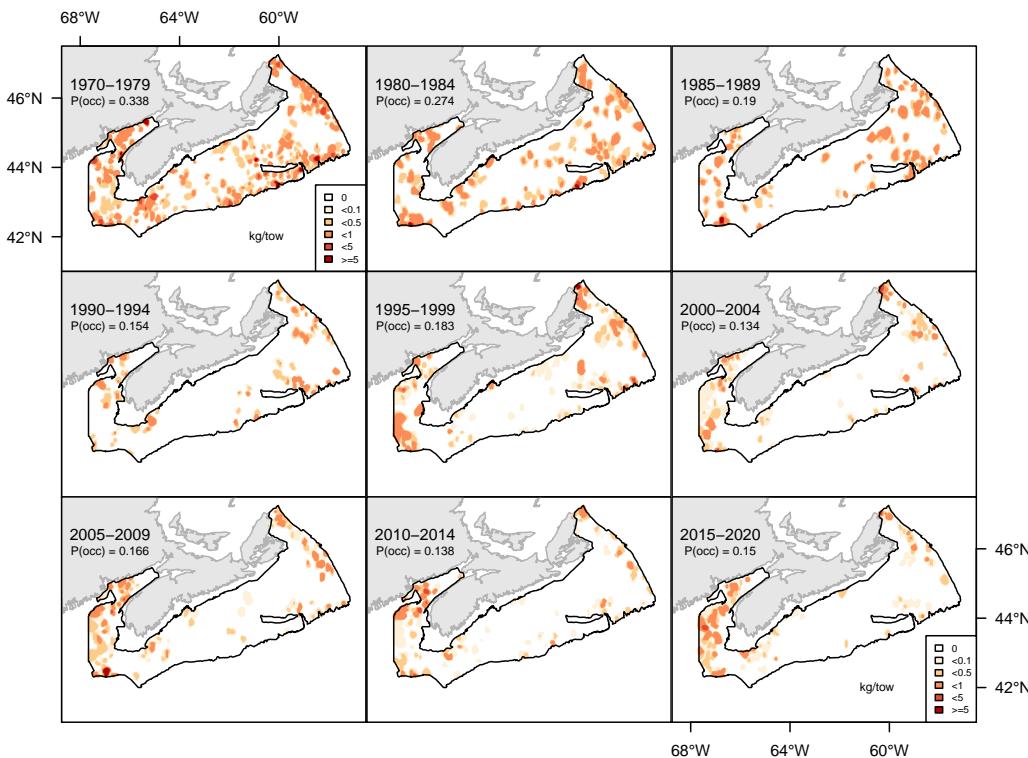


Figure 7.22A. Inverse distance weighted distribution of catch biomass (kg/tow) for Smooth skate.

891

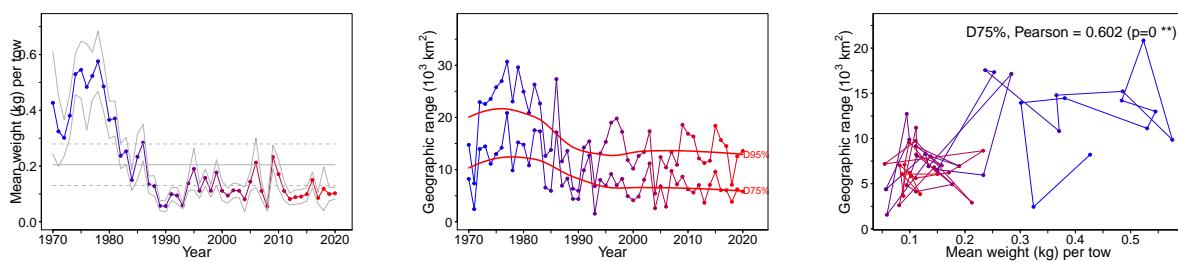


Figure 7.22B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Smooth skate.

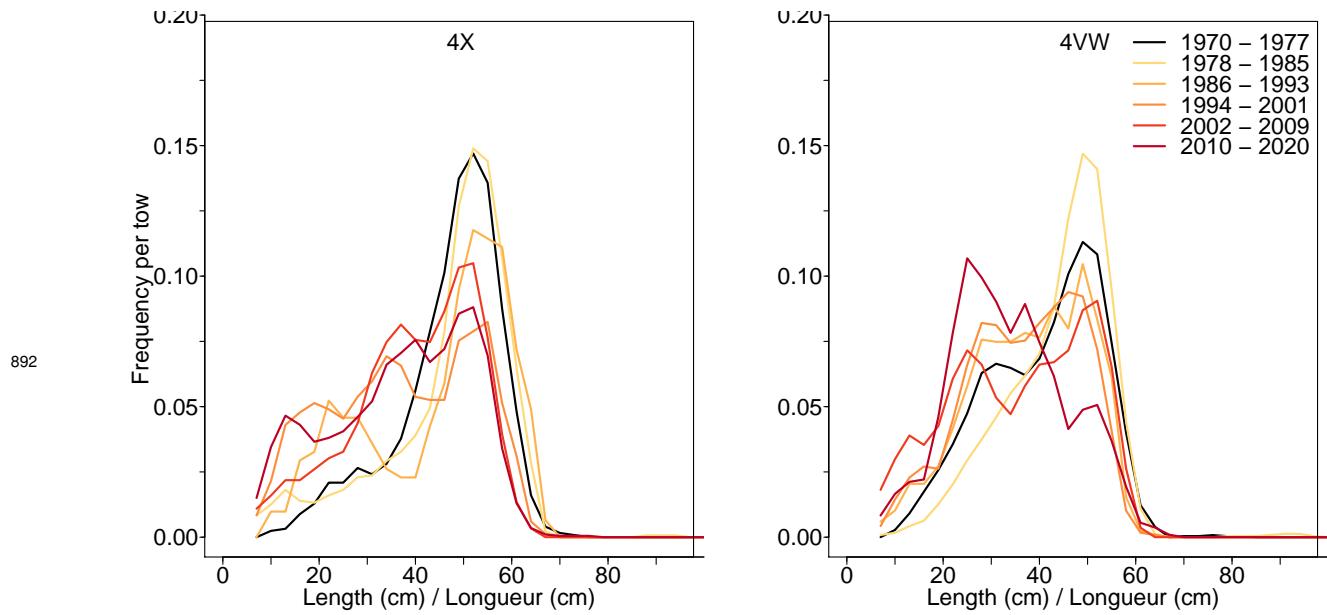


Figure 7.22C. Length frequency distribution in NAFO units 4X and 4VW for Smooth skate.

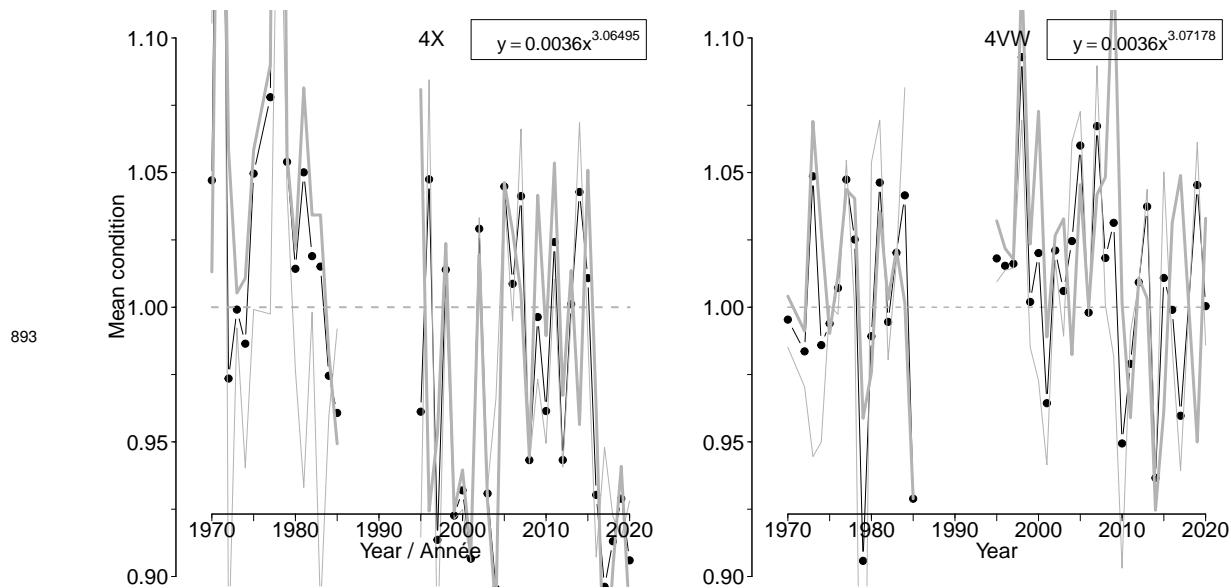
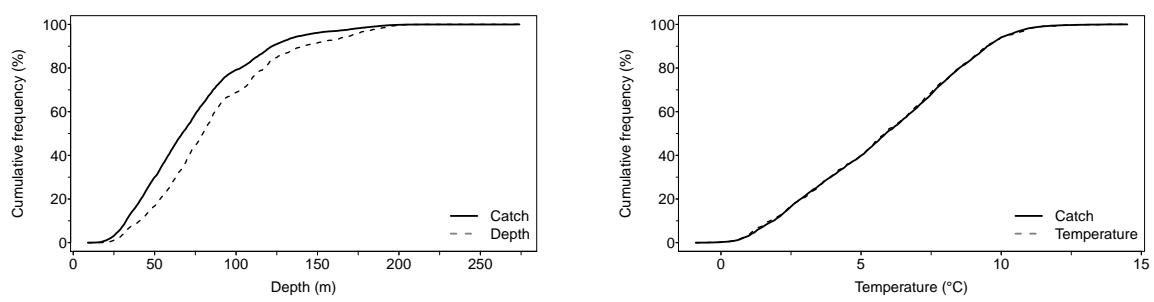
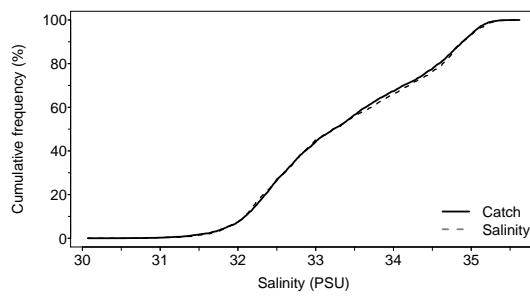


Figure 7.22D. Average fish condition in NAFO units 4X and 4VW for Smooth skate.



894



Freq	Depth	Temp	Sal
F5	33	1.2	31.00
F25	59	3.5	32.47
F50	80	5.9	33.23
F75	110	8.1	34.45
F95	171	10.0	35.06

Figure 7.22E. Catch distribution by depth, temperature and salinity of Smooth skate.

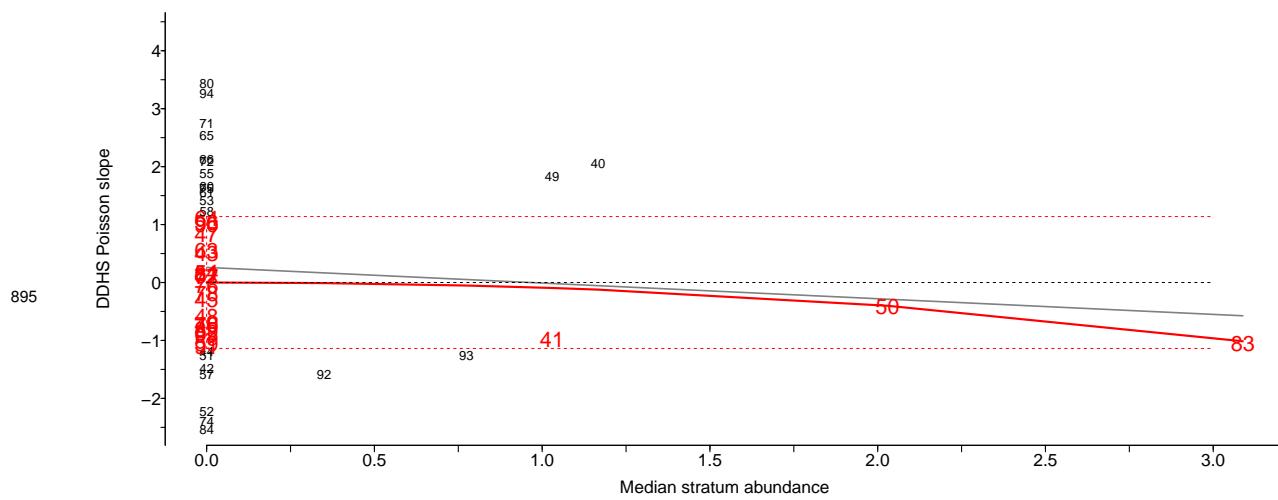


Figure 7.22F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Smooth skate.

896 **7.23 Winter skate (Raie tachetée) - species code 204 (category LF)**

897 Scientific name: [Leucoraja ocellata](#)

898

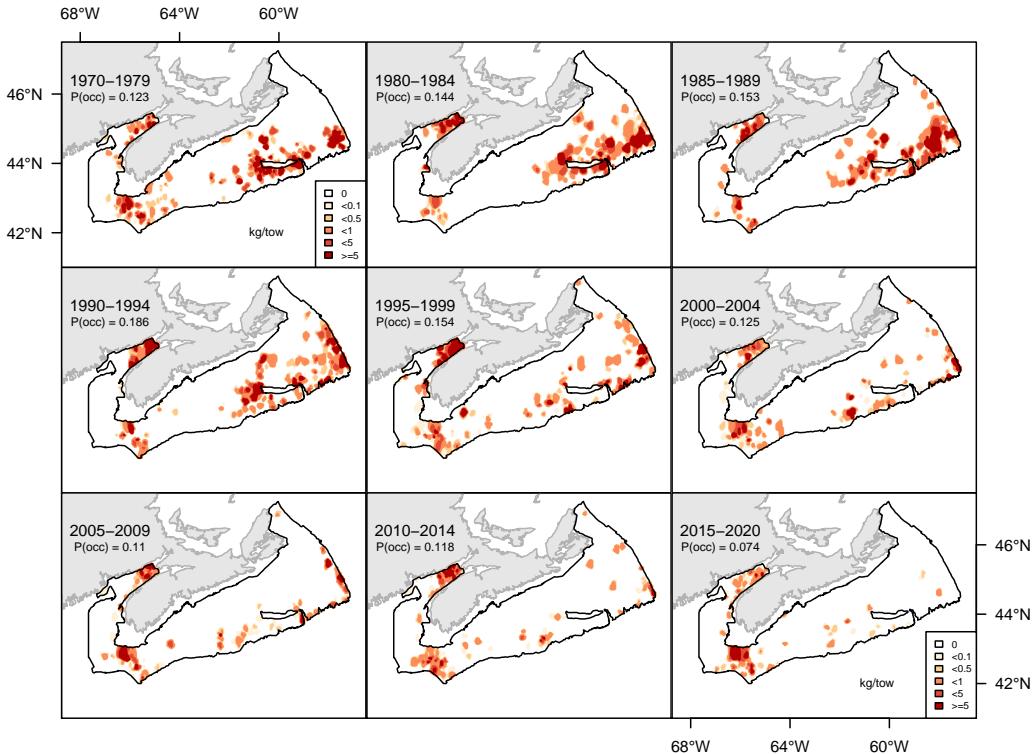


Figure 7.23A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter skate.

899

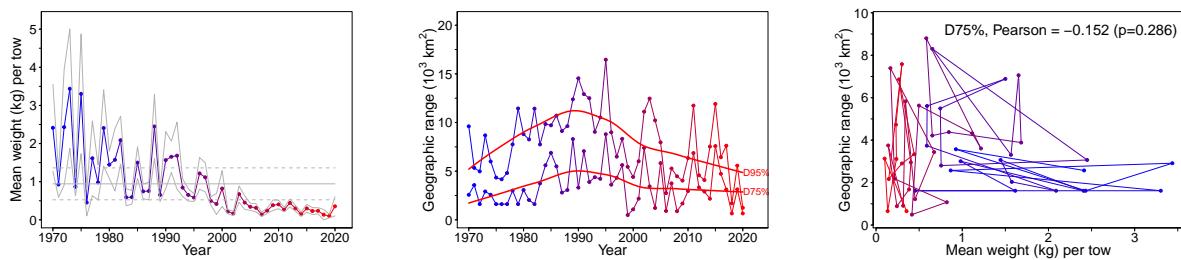


Figure 7.23B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter skate.

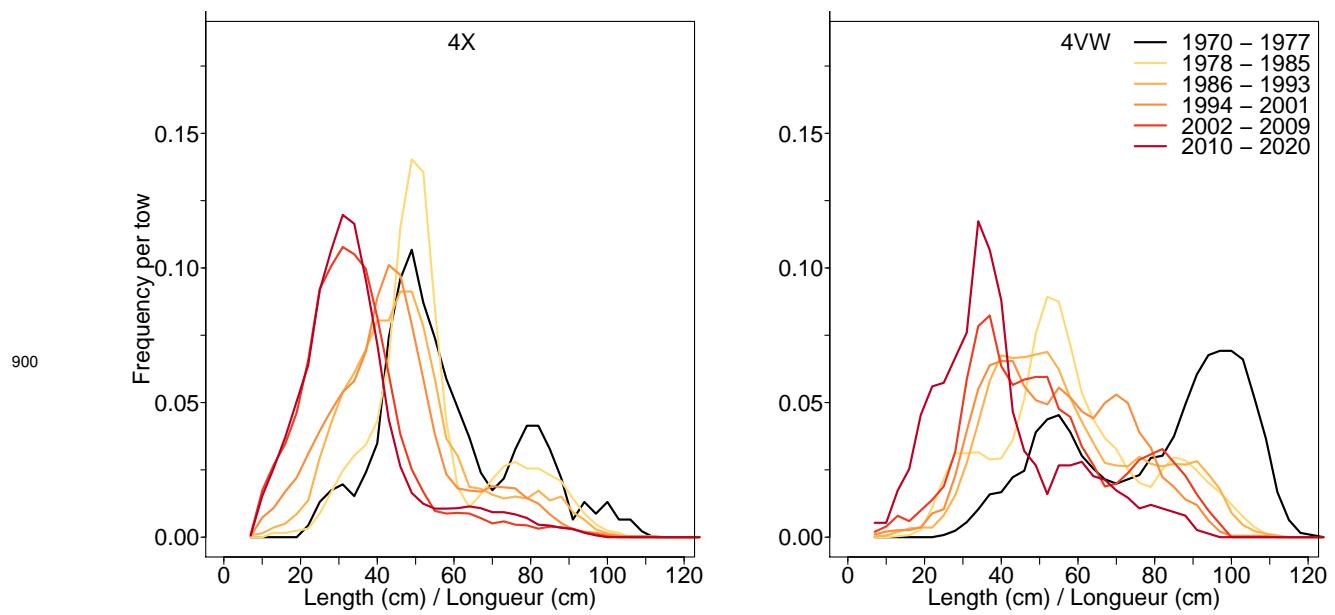


Figure 7.23C. Length frequency distribution in NAFO units 4X and 4VW for Winter skate.

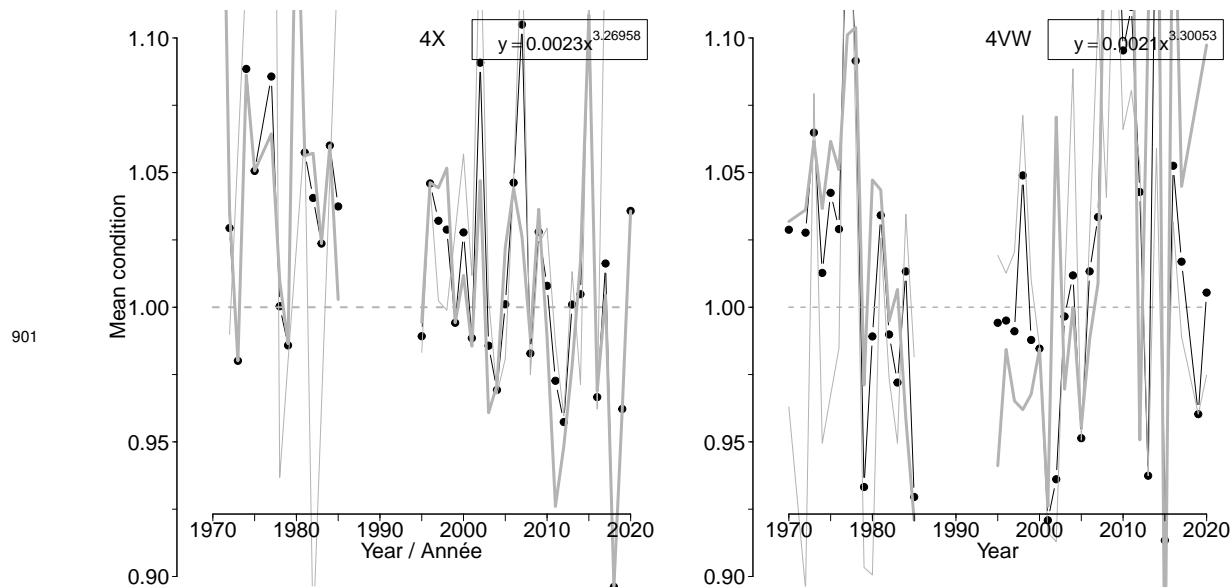
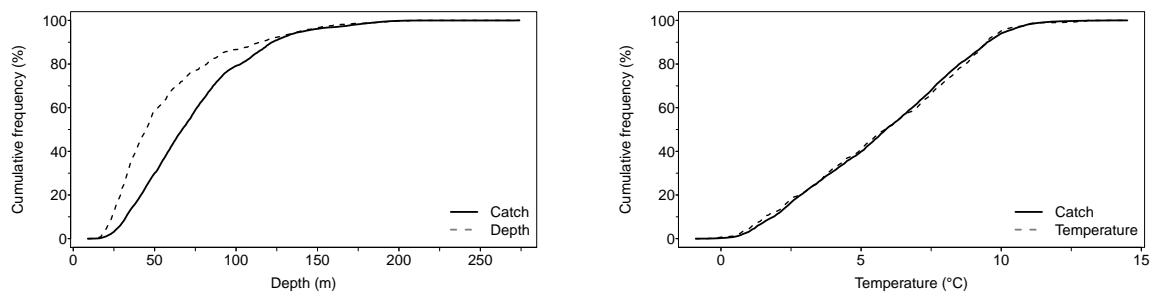
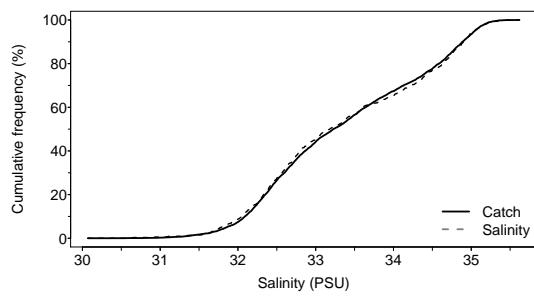


Figure 7.23D. Average fish condition in NAFO units 4X and 4VW for Winter skate.



902



Freq	Depth	Temp	Sal
F5	21	1.1	31.00
F25	32	3.5	32.44
F50	45	5.9	33.19
F75	71	8.3	34.42
F95	140	10.0	35.03

Figure 7.23E. Catch distribution by depth, temperature and salinity of Winter skate.

903

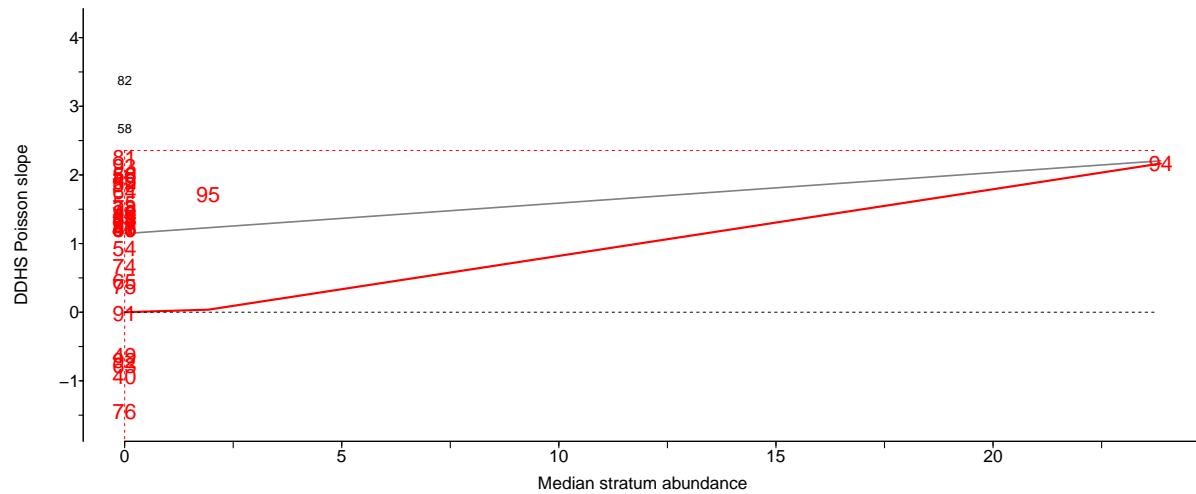


Figure 7.23F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Winter skate.

904

7.24 Picked dogfish (Aiguillat commun) - species code 220 (category LF)

905

Scientific name: [Squalus acanthias](#)

906

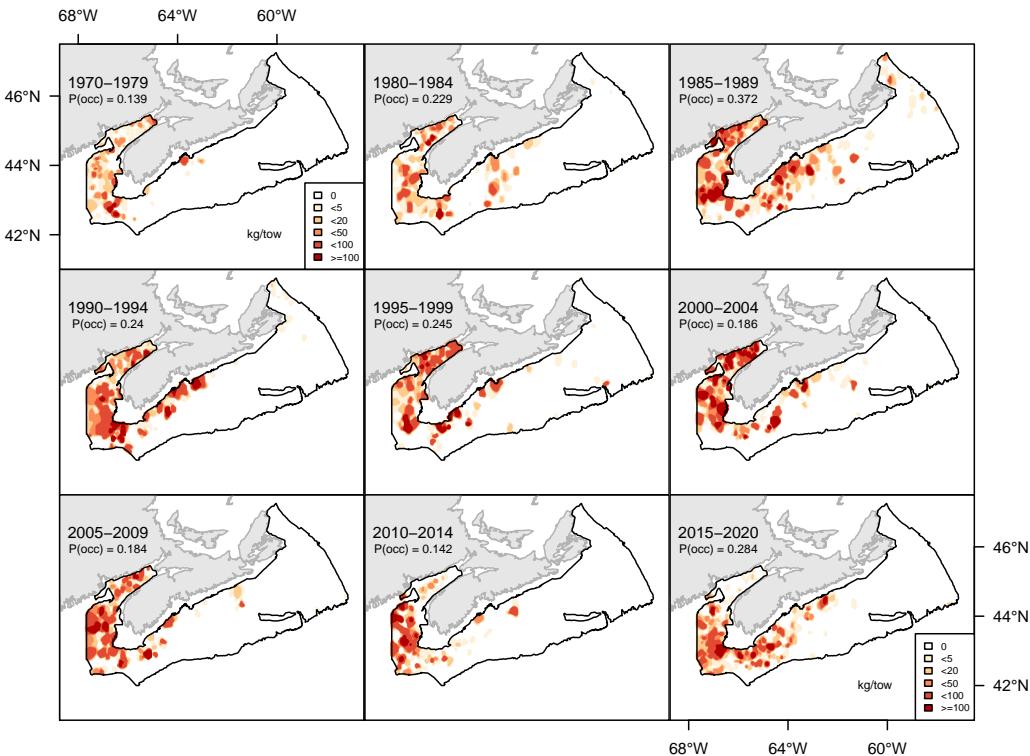


Figure 7.24A. Inverse distance weighted distribution of catch biomass (kg/tow) for Picked dogfish.

907

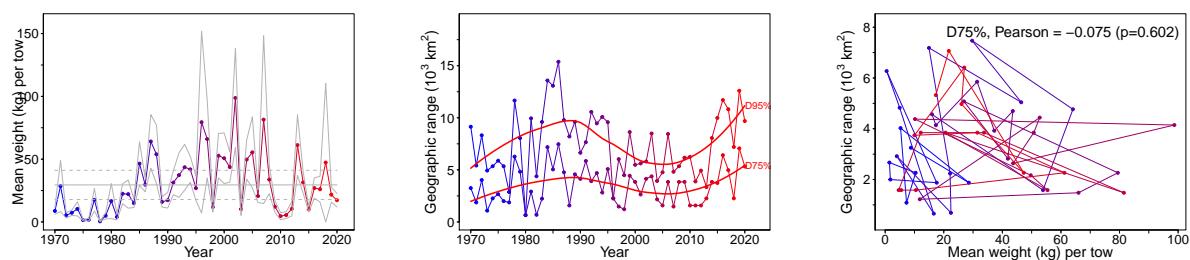


Figure 7.24B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Picked dogfish.

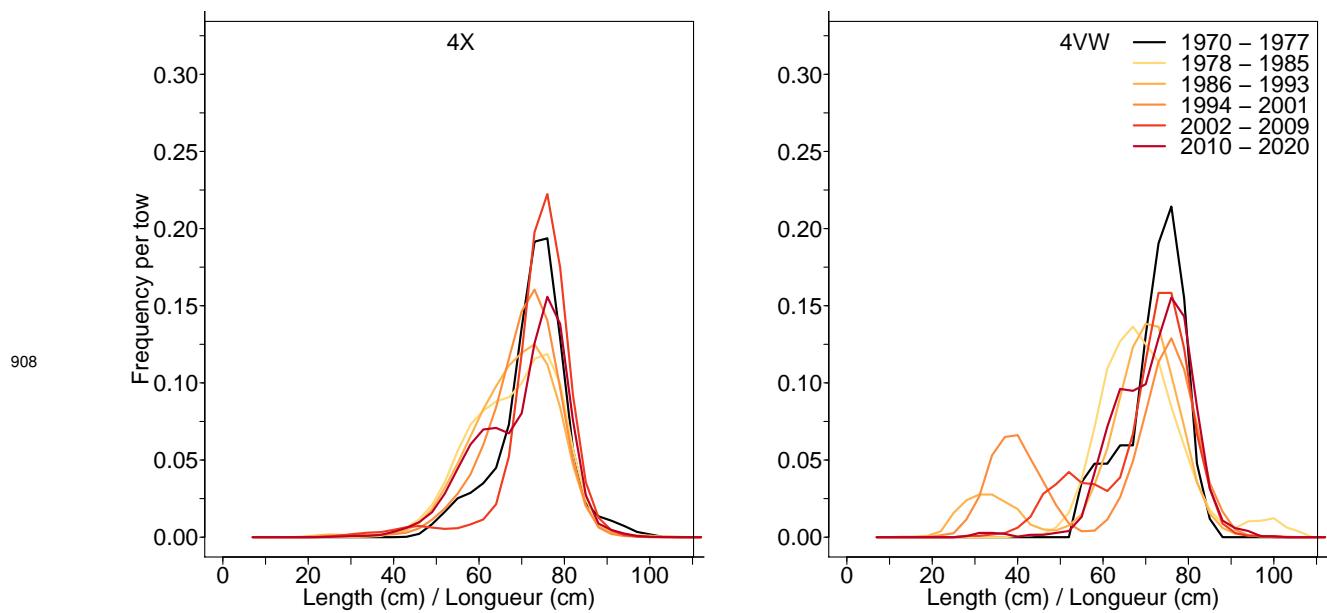


Figure 7.24C. Length frequency distribution in NAFO units 4X and 4VW for Picked dogfish.

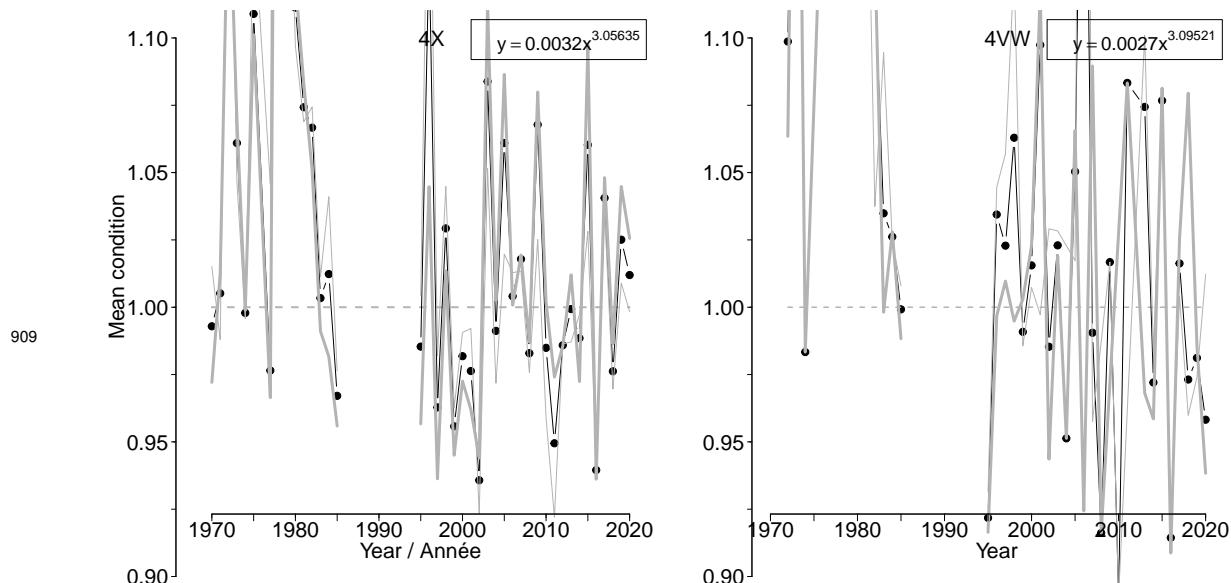
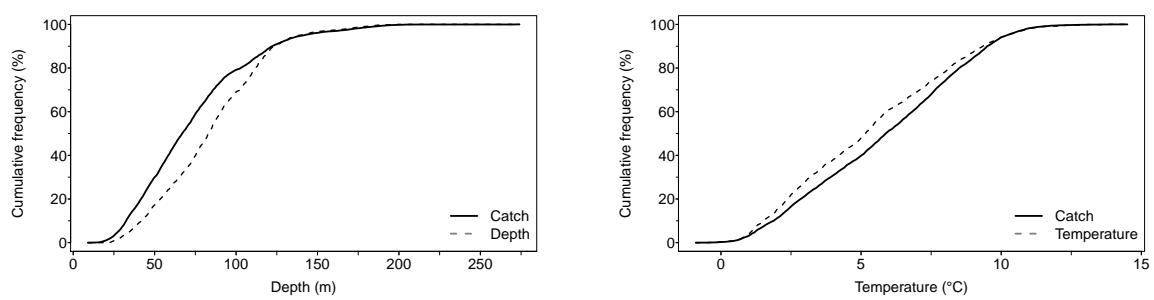
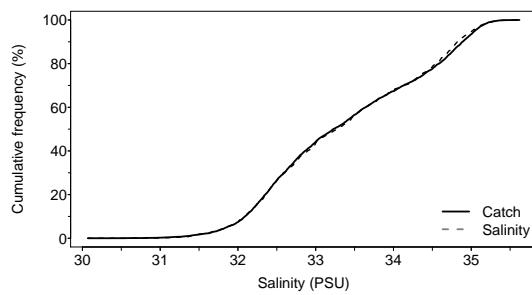


Figure 7.24D. Average fish condition in NAFO units 4X and 4VW for Picked dogfish.



910



Freq	Depth	Temp	Sal
F5	35	1.1	31.00
F25	60	2.8	32.47
F50	83	5.2	33.28
F75	108	7.7	34.37
F95	139	10.0	35.02

Figure 7.24E. Catch distribution by depth, temperature and salinity of Picked dogfish.

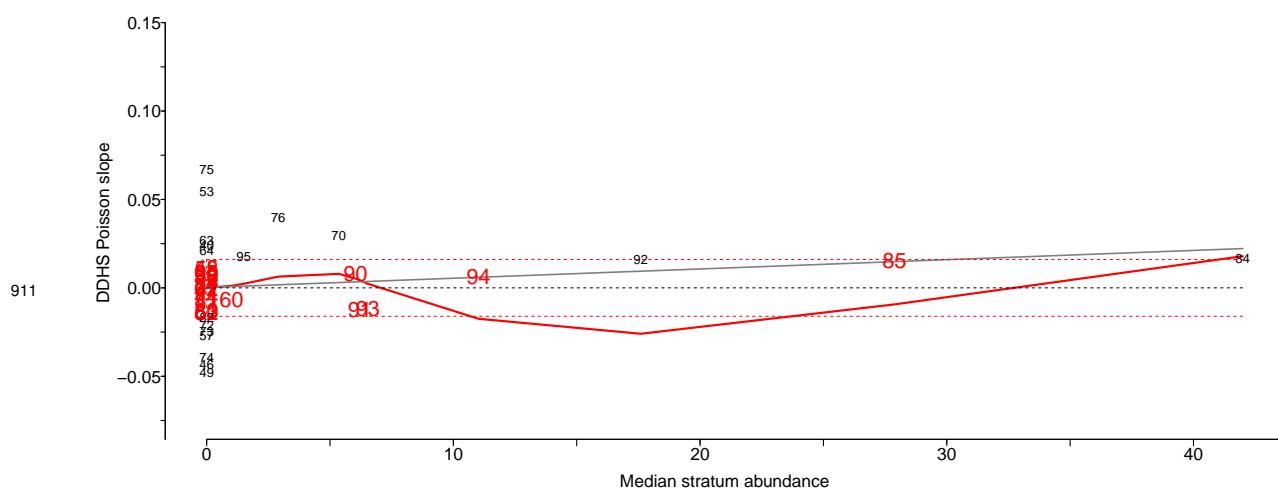


Figure 7.24F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Picked dogfish.

912 **7.25 Northern shortfin squid (*Encornet rouge nordique*) - species code 4511 (category**
 913 **LF)**

914 Scientific name: [Illex illecebrosus](#)

915

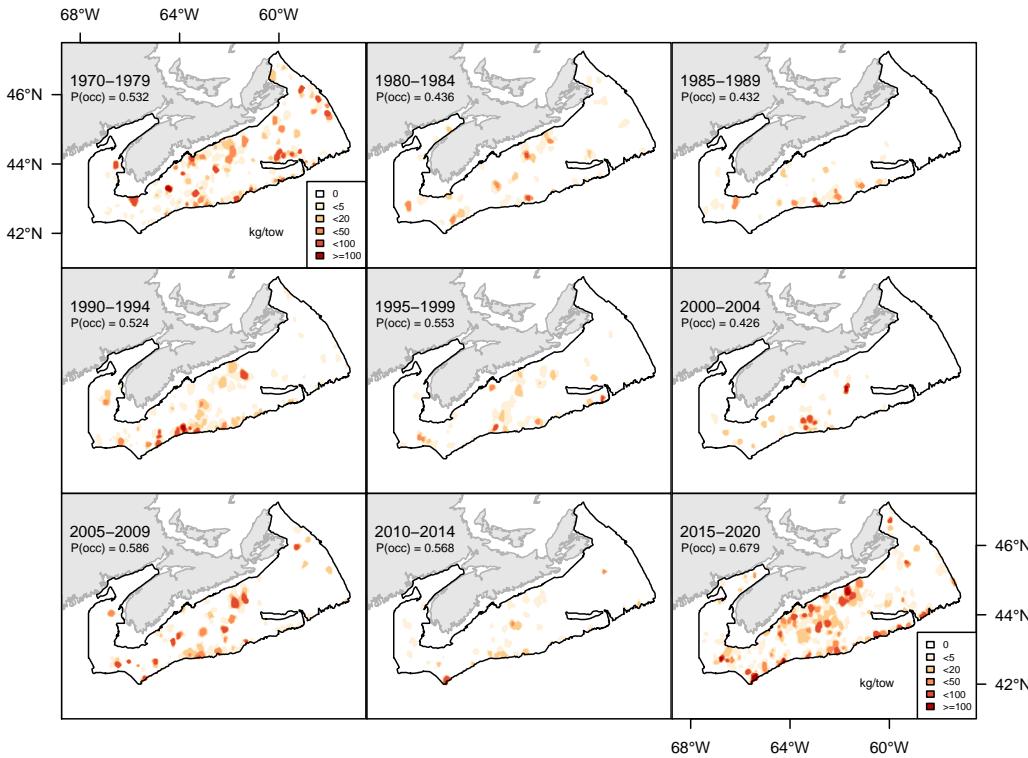


Figure 7.25A. Inverse distance weighted distribution of catch biomass (kg/tow) for Northern shortfin squid.

916

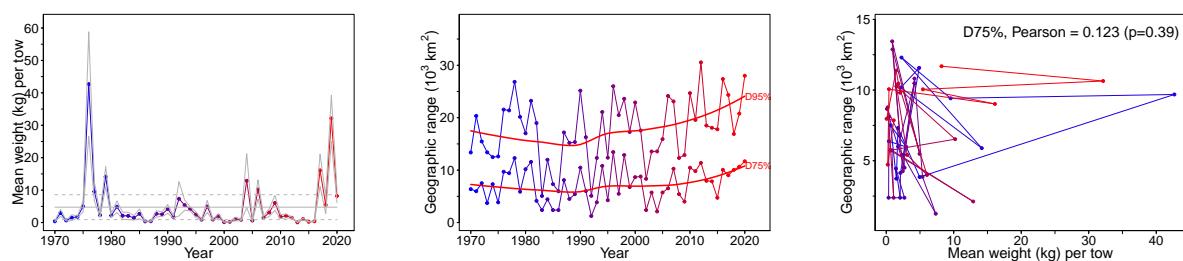


Figure 7.25B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Northern shortfin squid.

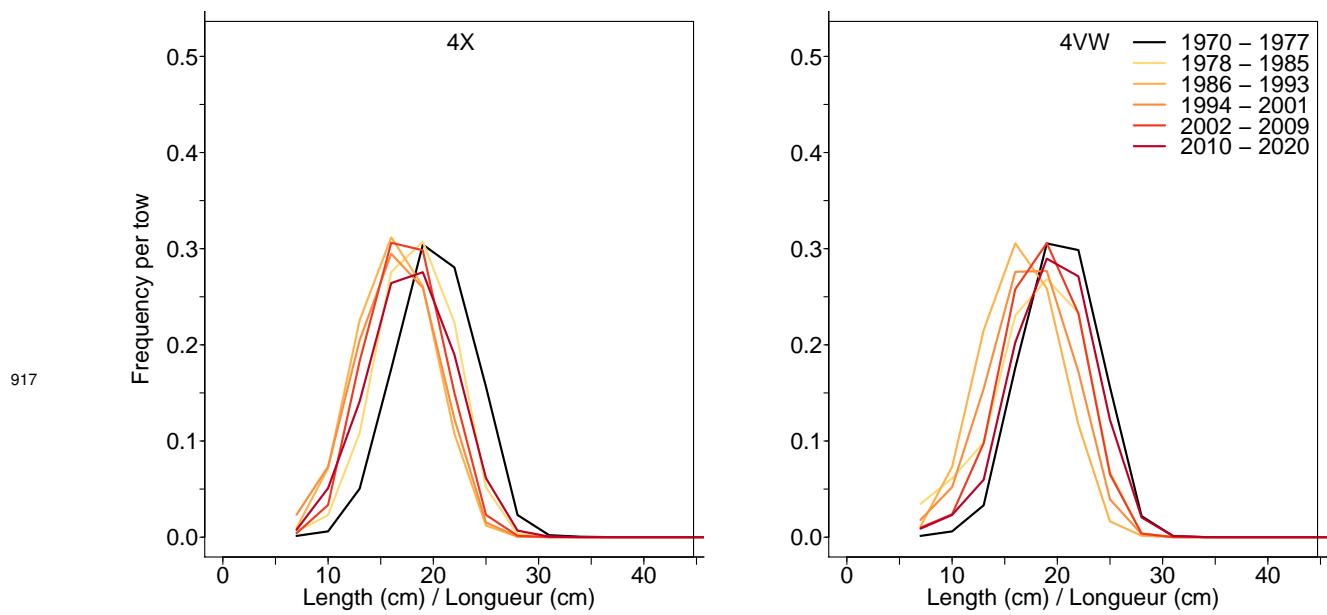


Figure 7.25C. Length frequency distribution in NAFO units 4X and 4VW for Northern shortfin squid.

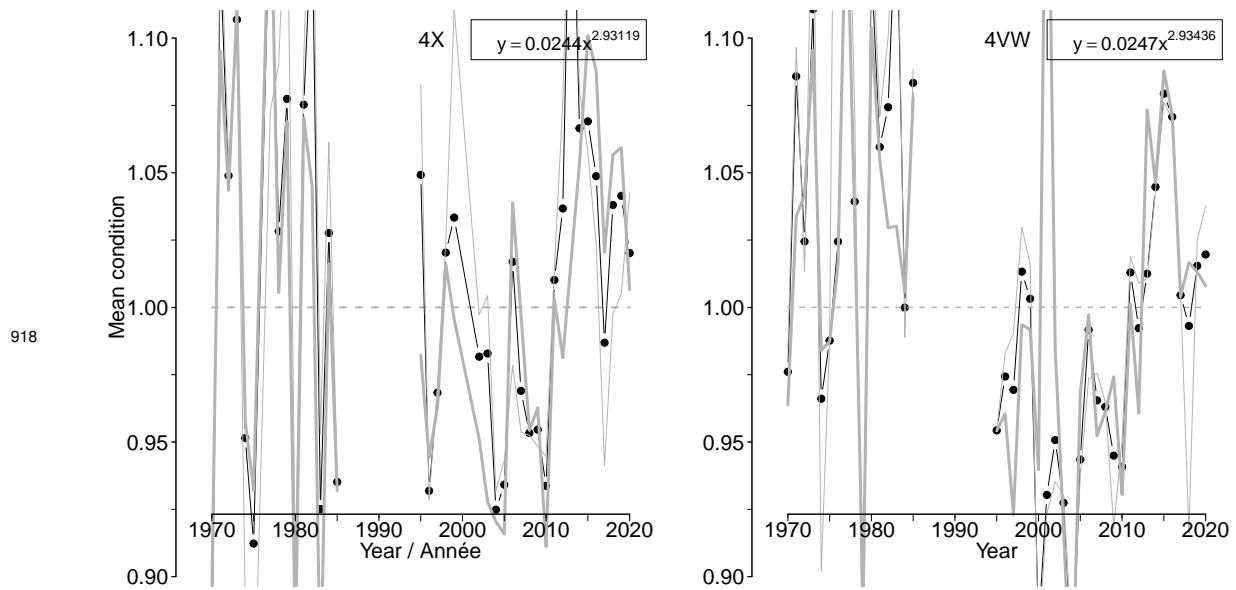
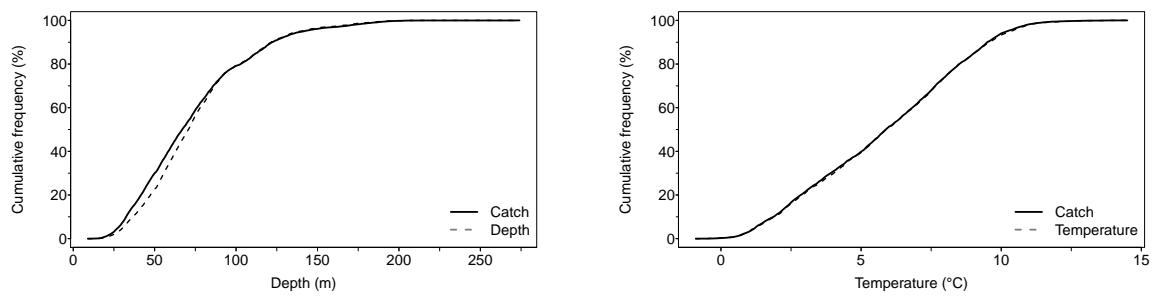
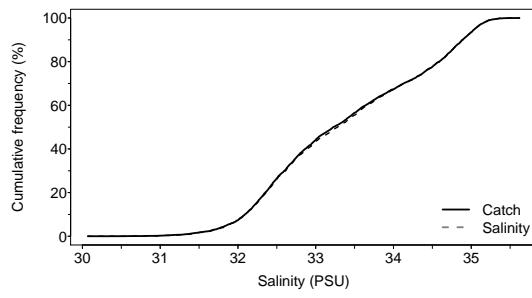


Figure 7.25D. Average fish condition in NAFO units 4X and 4VW for Northern shortfin squid.



919



Freq	Depth	Temp	Sal
F5	31	1.3	31.00
F25	53	3.5	32.48
F50	71	5.9	33.28
F75	93	8.1	34.39
F95	139	10.0	35.05

Figure 7.25E. Catch distribution by depth, temperature and salinity of Northern shortfin squid.

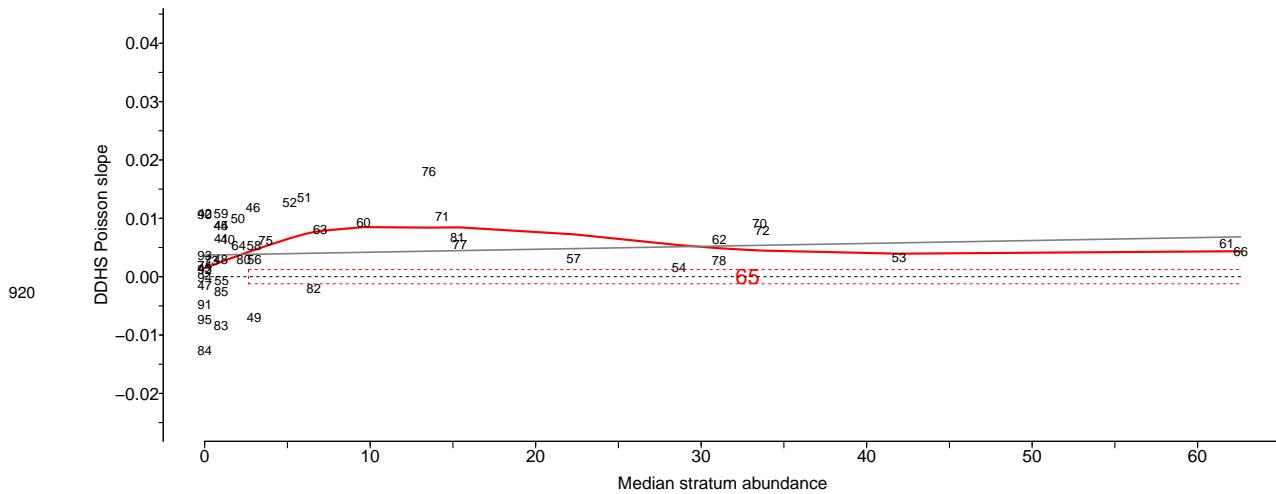


Figure 7.25F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Northern shortfin squid.

921

7.26 Atlantic hagfish (*Myxine du nord*) - species code 241 (category LI)

922

Scientific name: *Myxine glutinosa*

923

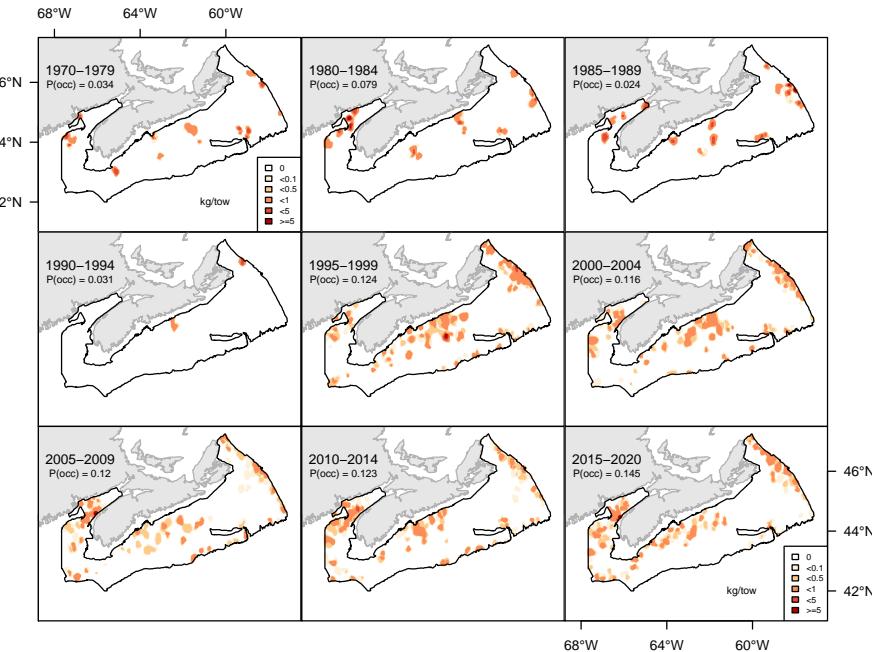


Figure 7.26A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic hagfish.

924

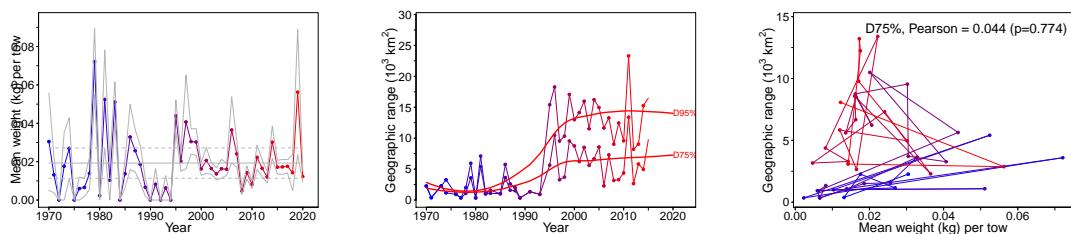


Figure 7.26B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hagfish.

925

7.27 Cusk (Brosme) - species code 15 (category LI)

926

Scientific name: [Brosme brosme](#)

927

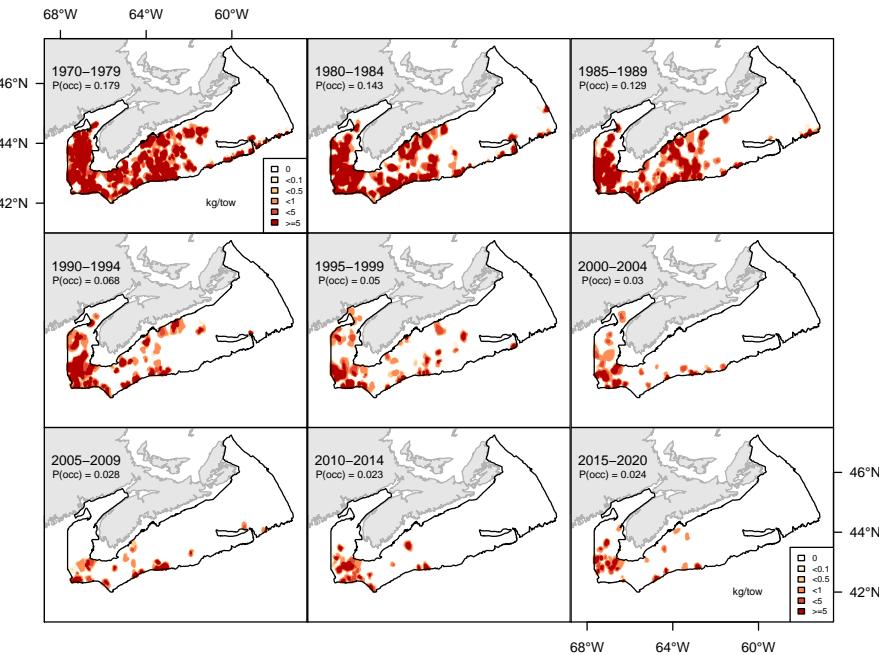


Figure 7.27A. Inverse distance weighted distribution of catch biomass (kg/tow) for Cusk.

928

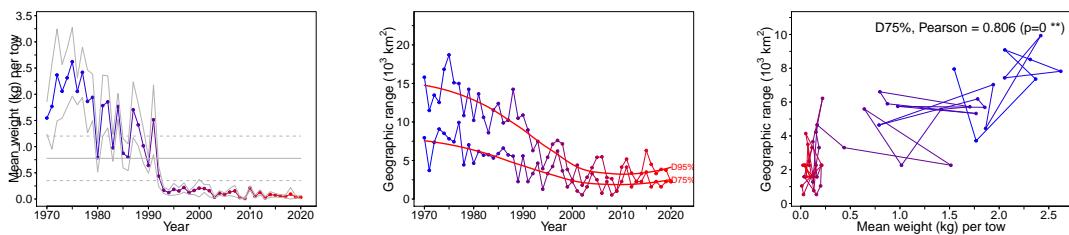


Figure 7.27B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Cusk.

929

7.28 Greenland halibut (Flétan noir) - species code 31 (category LI)

930

Scientific name: [Reinhardtius hippoglossoides](#)

931

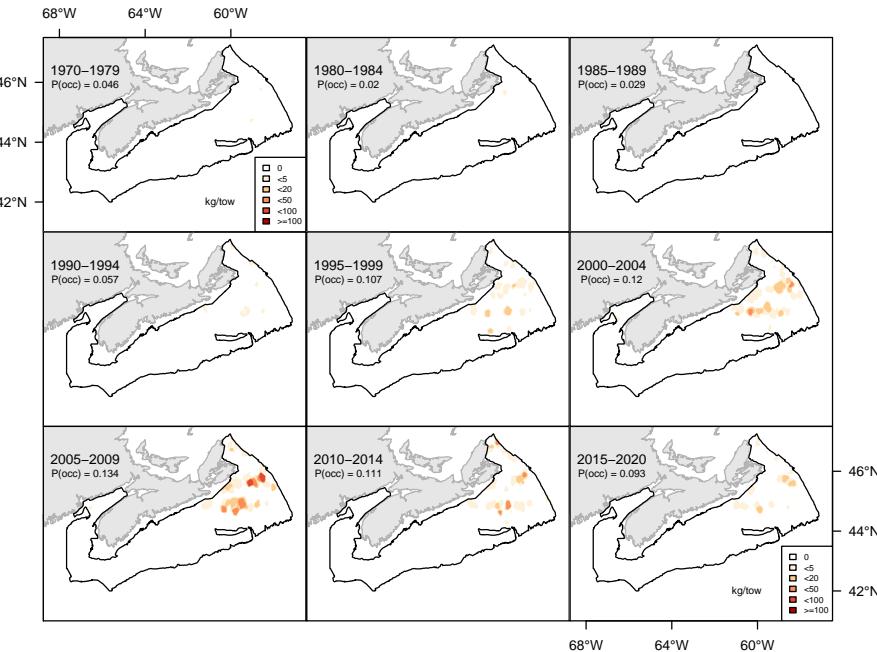


Figure 7.28A. Inverse distance weighted distribution of catch biomass (kg/tow) for Greenland halibut.

932

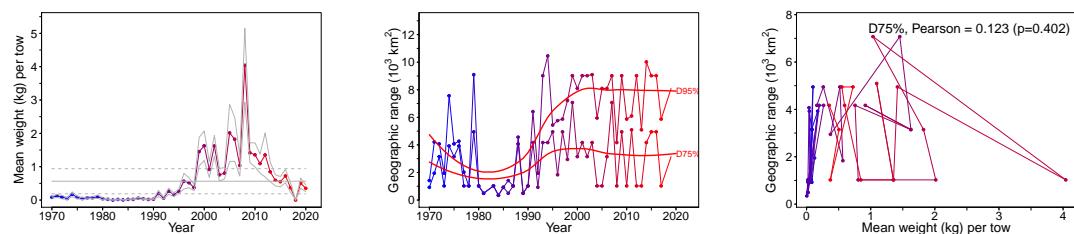


Figure 7.28B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greenland halibut.

933 **7.29 Gulf Stream flounder (Plie du Gulf Stream) - species code 44 (category LI)**

934 Scientific name: [Citharichthys arctifrons](#)

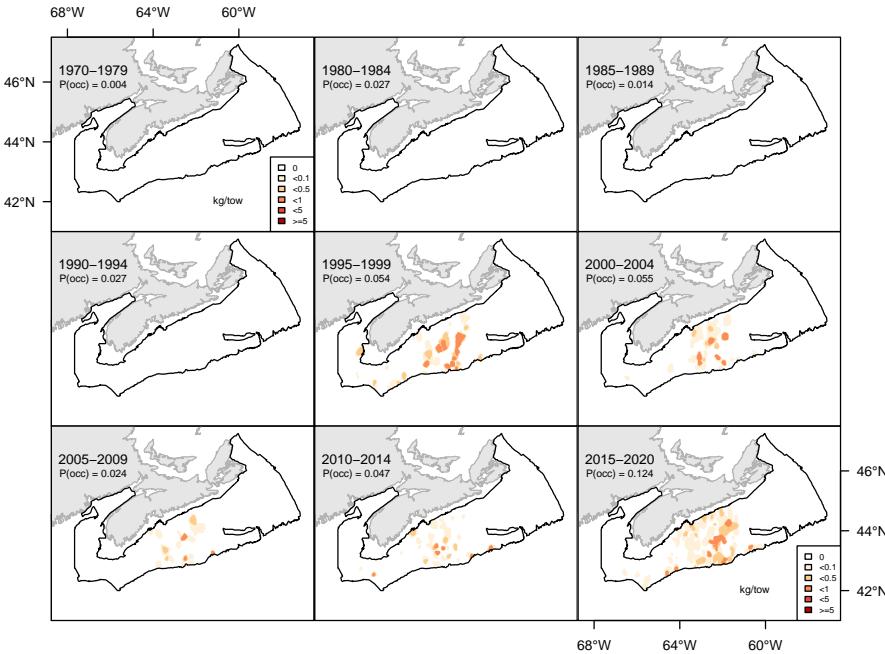


Figure 7.29A. Inverse distance weighted distribution of catch biomass (kg/tow) for Gulf Stream flounder.

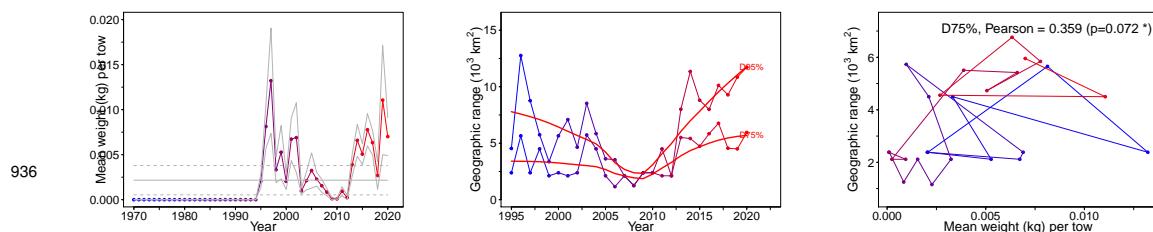


Figure 7.29B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Gulf Stream flounder.

937

7.30 American shad (*Alose savoureuse*) - species code 61 (category LI)

938

Scientific name: [Alosa sapidissima](#)

939

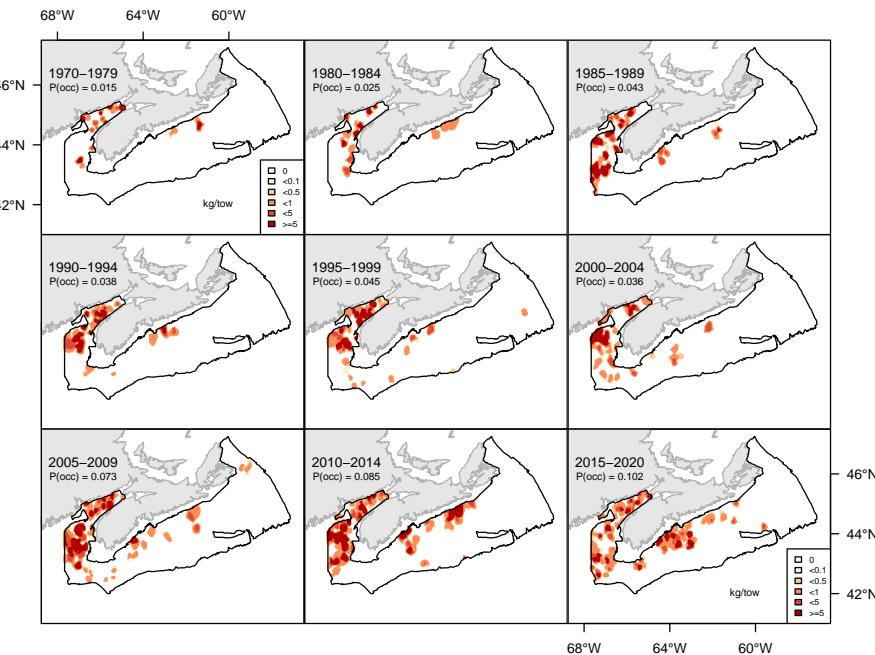


Figure 7.30A. Inverse distance weighted distribution of catch biomass (kg/tow) for American shad.

940

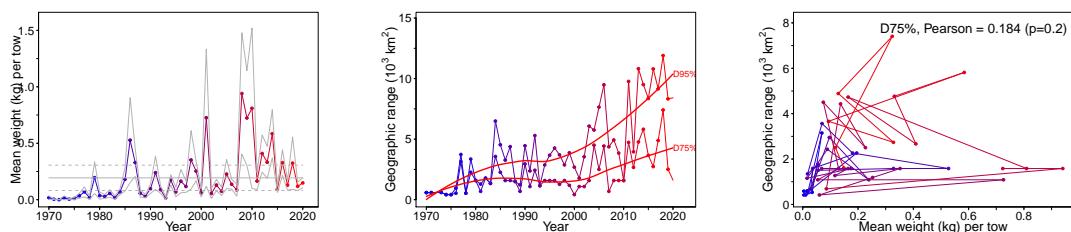


Figure 7.30B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American shad.

941

7.31 Alewife (Gaspareau) - species code 62 (category LI)

942

Scientific name: *Alosa pseudoharengus*

943

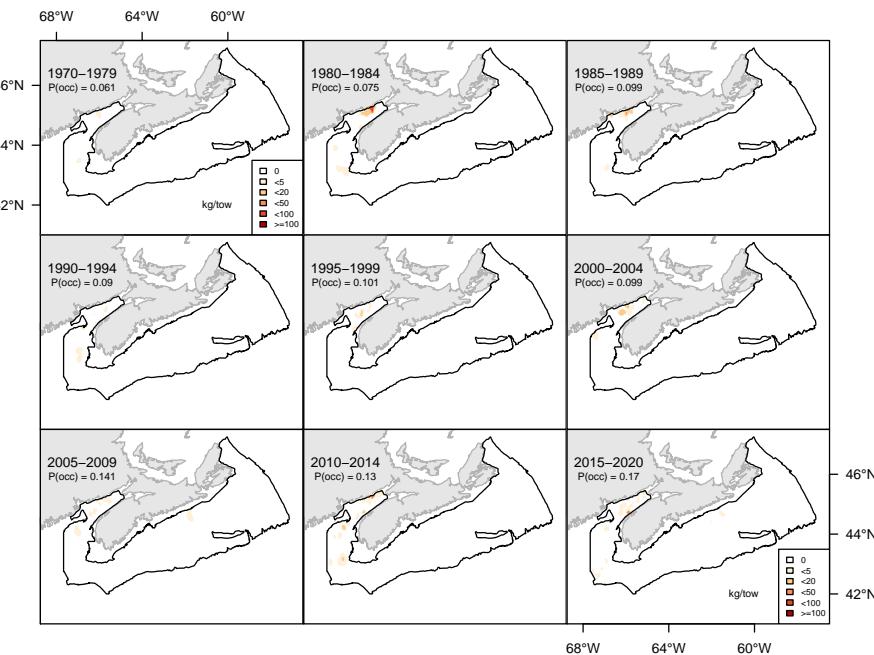


Figure 7.31A. Inverse distance weighted distribution of catch biomass (kg/tow) for Alewife.

944

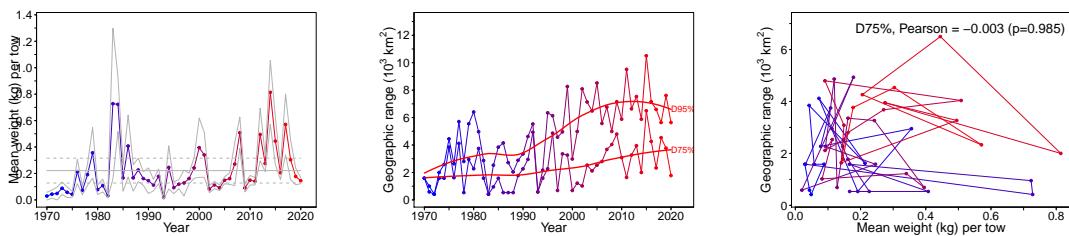


Figure 7.31B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alewife.

945

7.32 Capelin (Capelan) - species code 64 (category LI)

946

Scientific name: [Mallotus villosus](#)

947

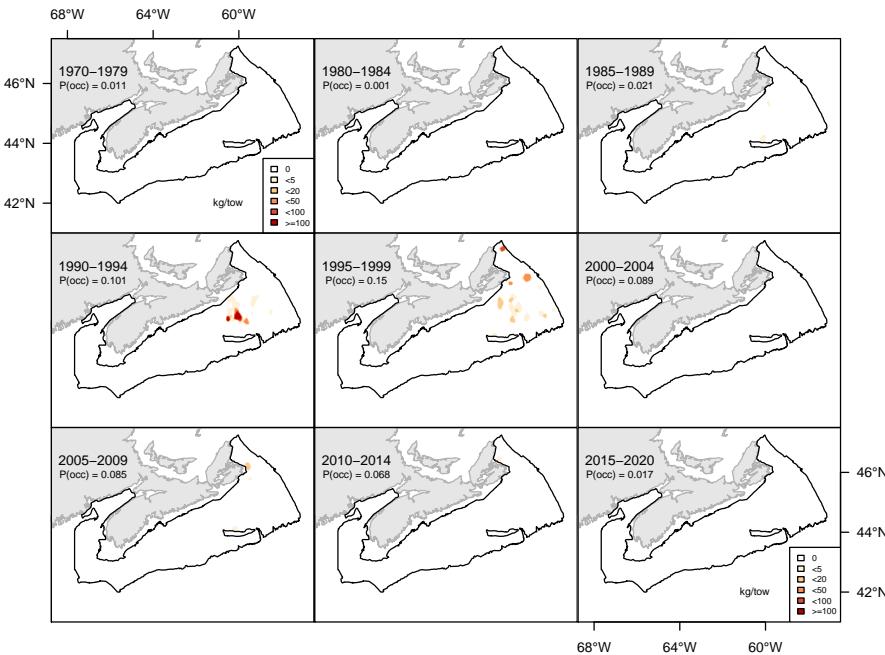


Figure 7.32A. Inverse distance weighted distribution of catch biomass (kg/tow) for Capelin.

948

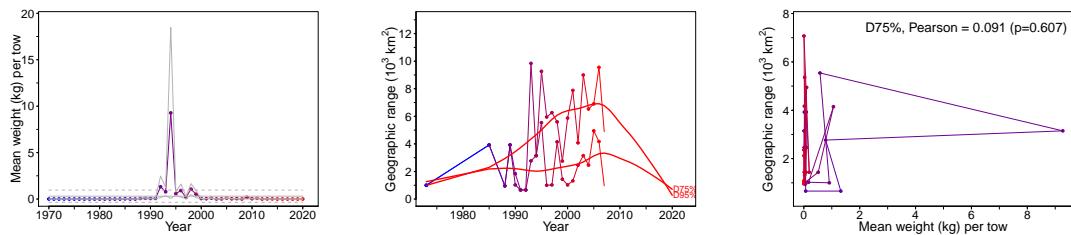


Figure 7.32B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Capelin.

949 **7.33 Atlantic mackerel (*Maquereau commun*) - species code 70 (category LI)**

950 Scientific name: *Scomber scombrus*

951

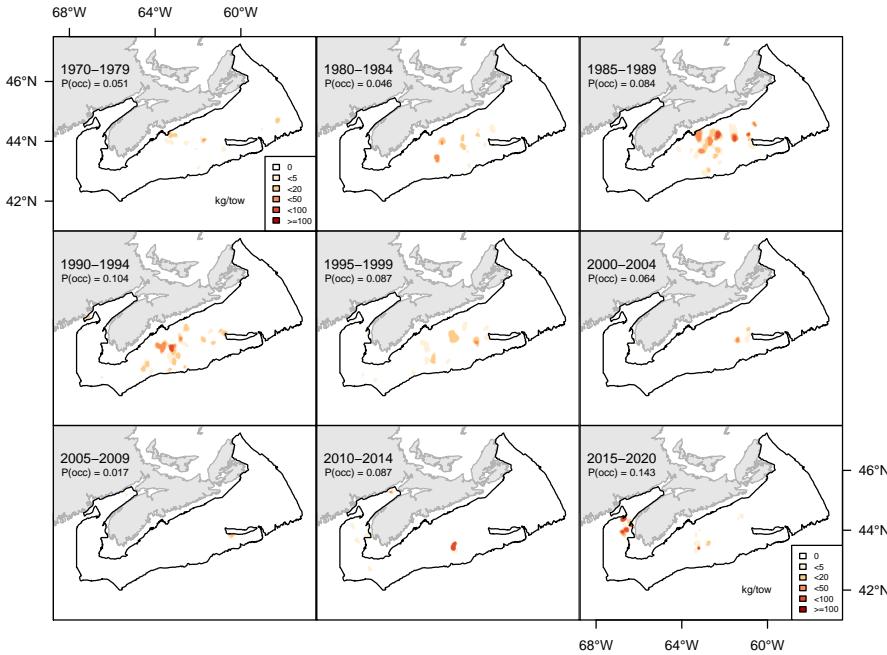


Figure 7.33A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic mackerel.

952

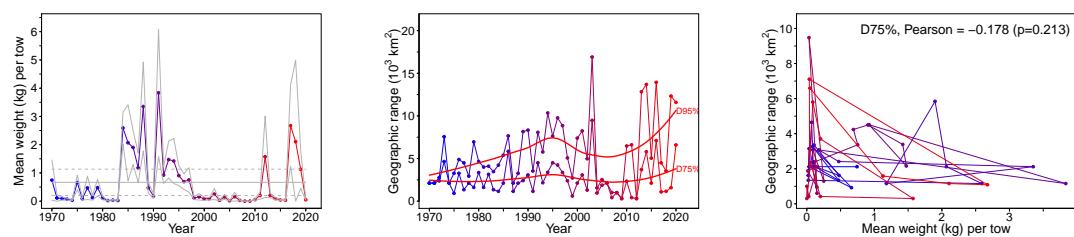


Figure 7.33B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic mackerel.

953

7.34 Longfin hake (*Merluche à longues nageoires*) - species code 112 (category LI)

954

Scientific name: *Phycis chesteri*

955

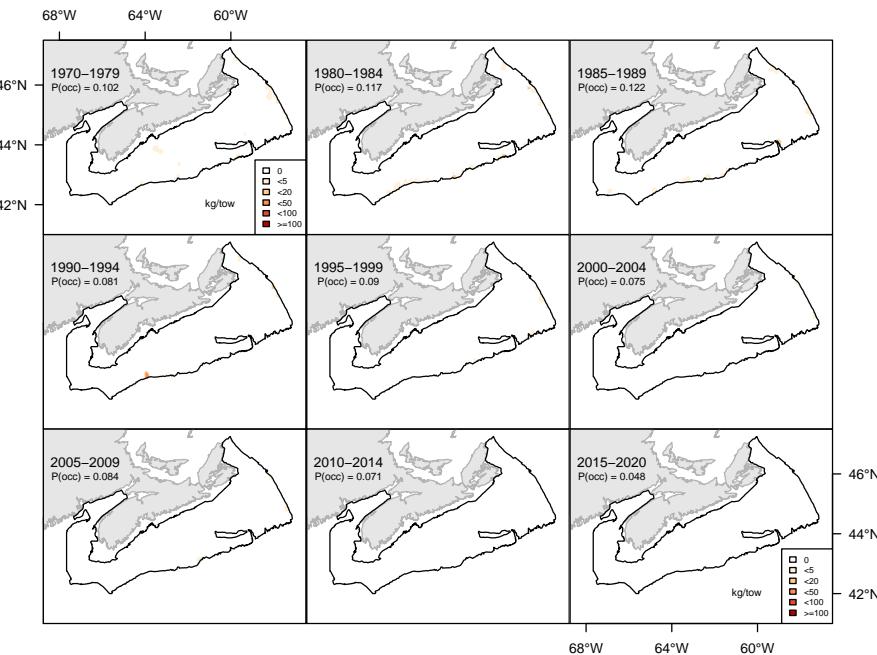


Figure 7.34A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longfin hake.

956

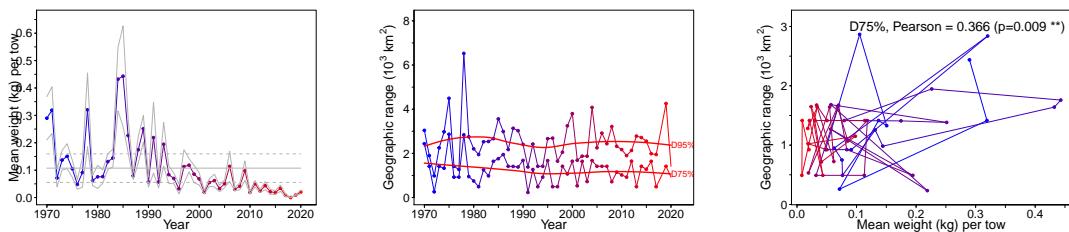


Figure 7.34B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longfin hake.

957

7.35 Fourbeard rockling (Motelle à quatre barbillons) - species code 114 (category LI)

958

Scientific name: [Enchelyopus cimbrius](#)

959

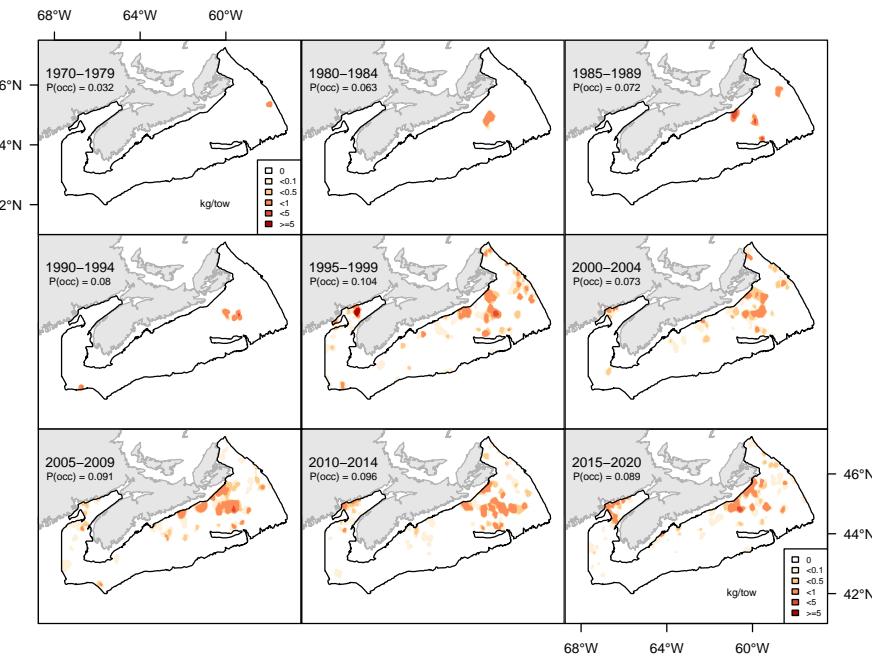


Figure 7.35A. Inverse distance weighted distribution of catch biomass (kg/tow) for Fourbeard rockling.

960

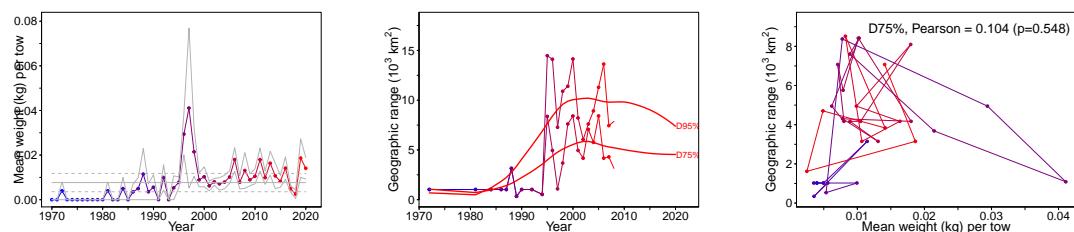


Figure 7.35B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Fourbeard rockling.

961 **7.36 Blackbelly rosefish (Sébaste chèvre) - species code 123 (category LI)**

962 Scientific name: [Helicolenus dactylopterus](#)

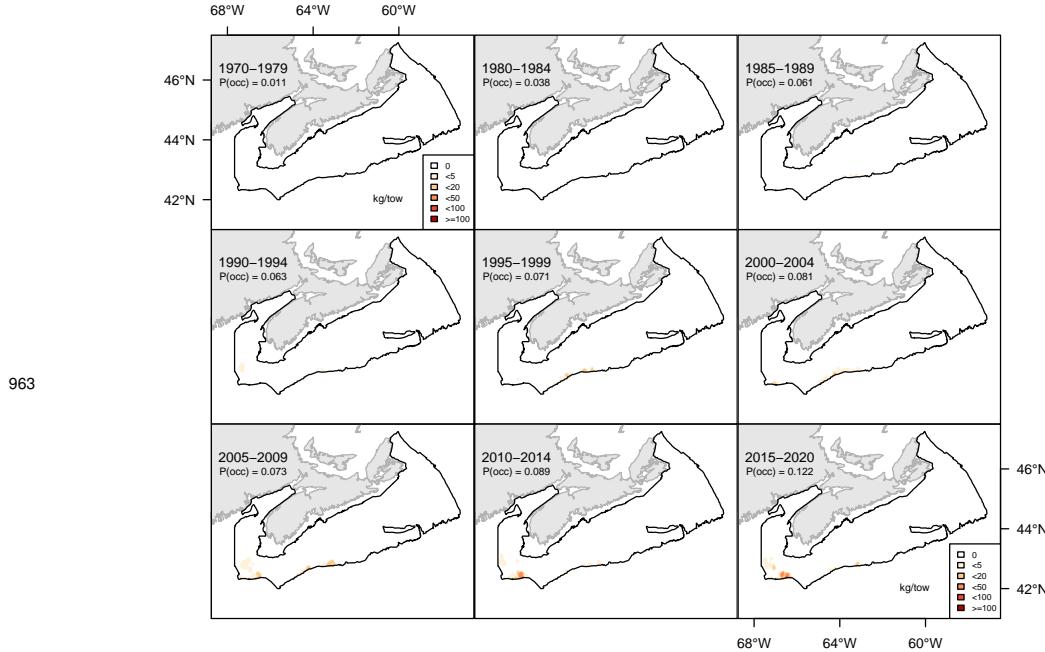


Figure 7.36A. Inverse distance weighted distribution of catch biomass (kg/tow) for Blackbelly rosefish.

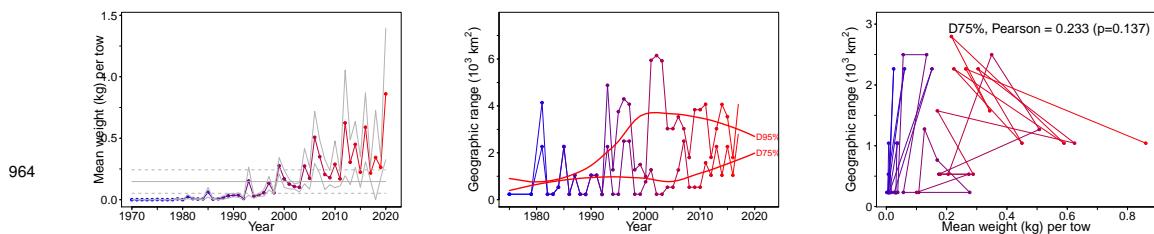


Figure 7.36B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Blackbelly rosefish.

965 **7.37 Greater argentine (Grande argentine) - species code 160 (category LI)**

966 Scientific name: [Argentina silus](#)

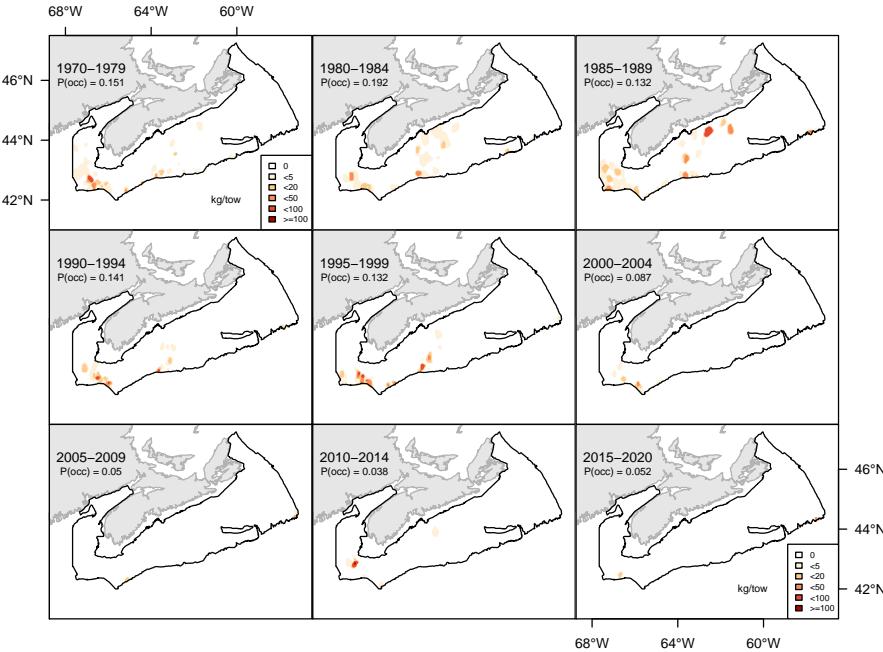


Figure 7.37A. Inverse distance weighted distribution of catch biomass (kg/tow) for Greater argentine.

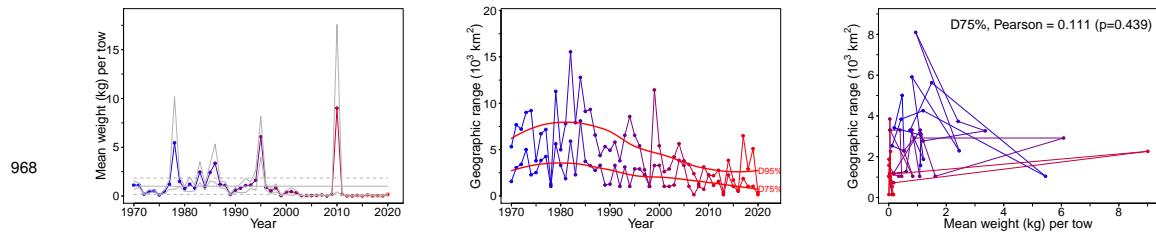


Figure 7.37B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greater argentine.

969 **7.38 Arctic hookear sculpin (*Hameçon neigeux*) - species code 306 (category LI)**

970 Scientific name: [Artediellus uncinatus](#)

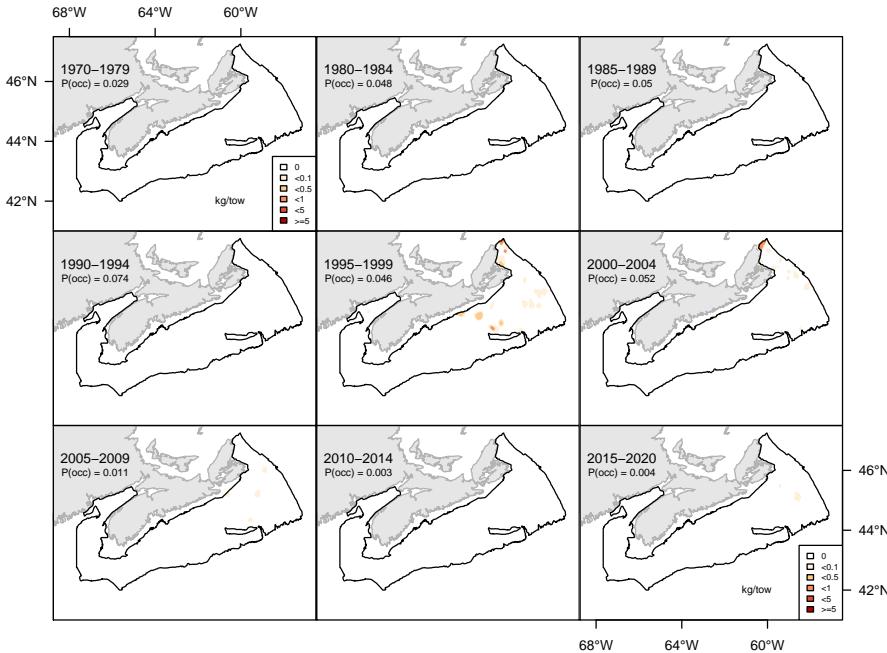


Figure 7.38A. Inverse distance weighted distribution of catch biomass (kg/tow) for Arctic hookear sculpin.

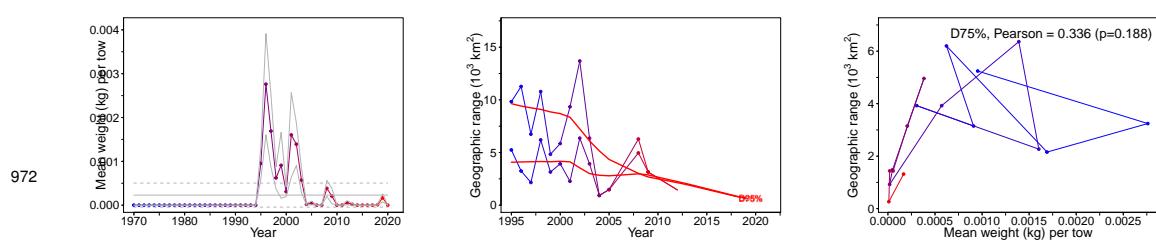


Figure 7.38B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic hookear sculpin.

973

7.39 Atlantic poacher (*Agone atlantique*) - species code 350 (category LI)

974

Scientific name: [Leptagonus decagonus](#)

975

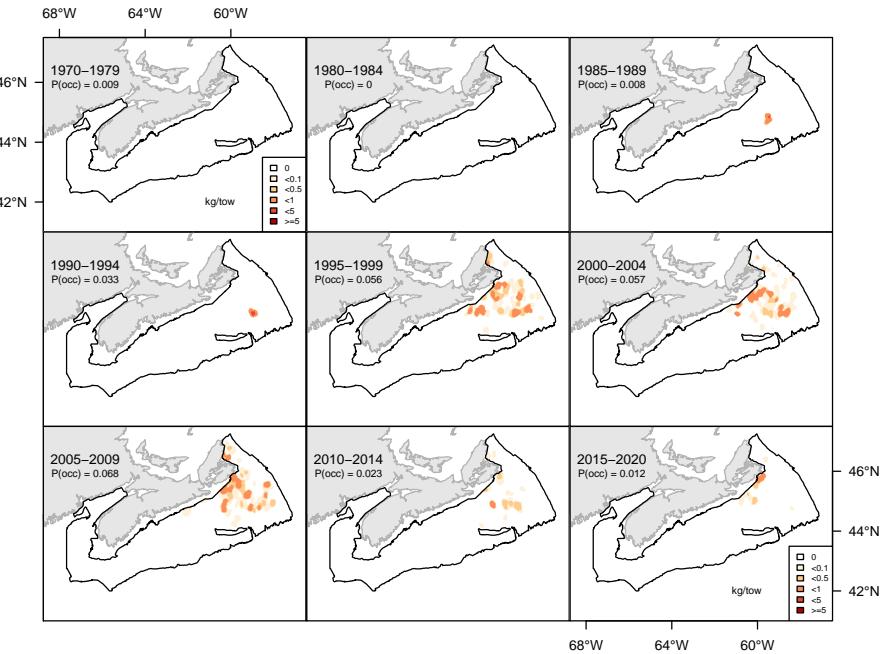


Figure 7.39A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic poacher.

976

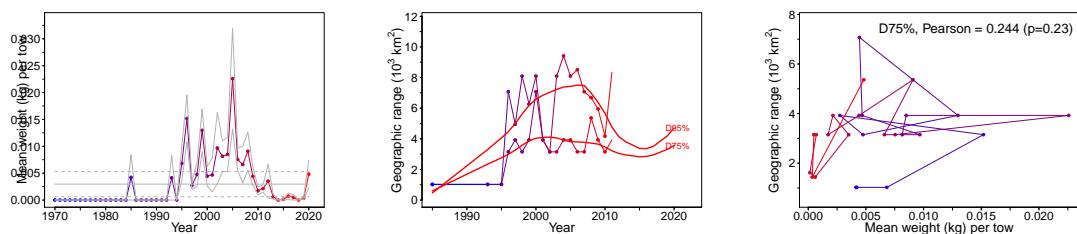


Figure 7.39B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic poacher.

977 **7.40 Marlin-spike grenadier (Grenadier du Grand Banc) - species code 410 (category**
 978 **LI)**

979 Scientific name: [Nezumia bairdii](#)

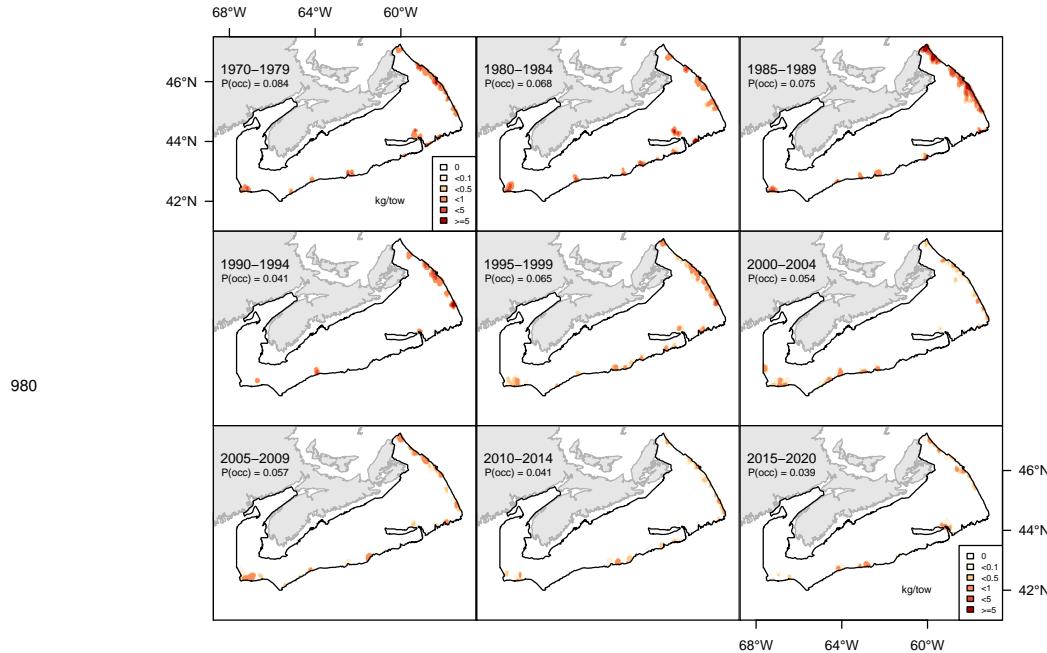


Figure 7.40A. Inverse distance weighted distribution of catch biomass (kg/tow) for Marlin-spike grenadier.

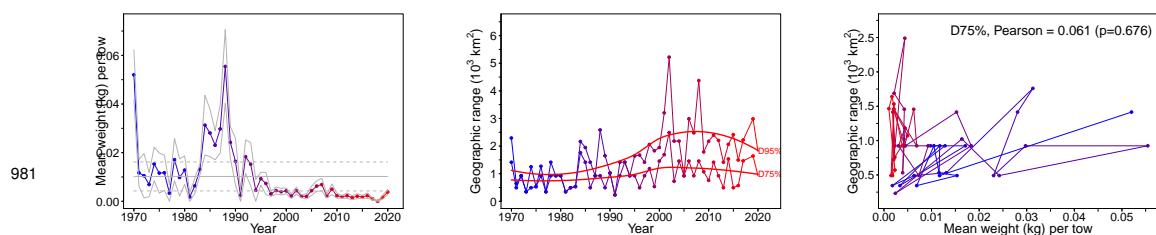


Figure 7.40B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Marlin-spike grenadier.

982

7.41 Lumpfish (Lompe) - species code 501 (category LI)

983

Scientific name: [Cyclopterus lumpus](#)

984

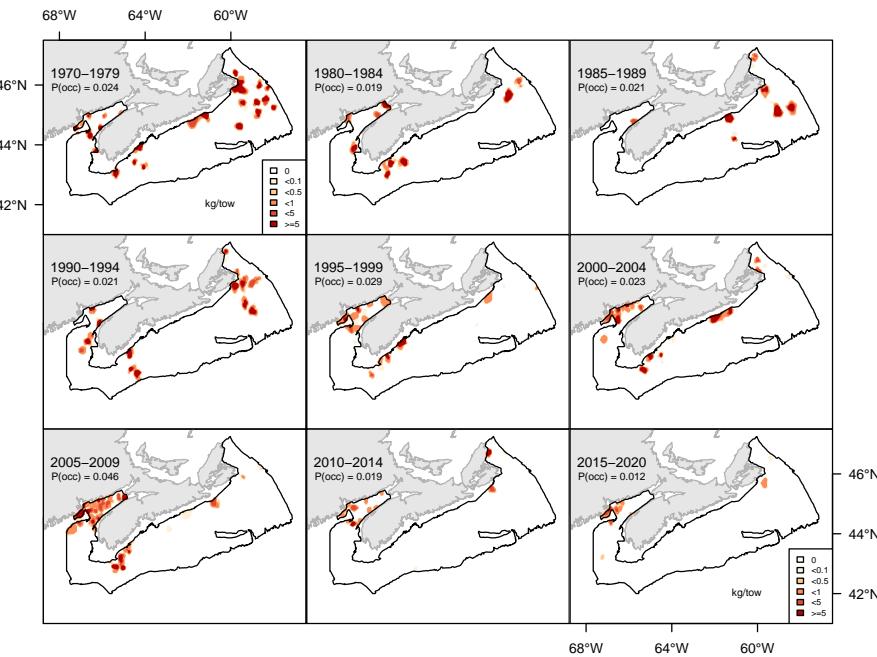


Figure 7.41A. Inverse distance weighted distribution of catch biomass (kg/tow) for Lumpfish.

985

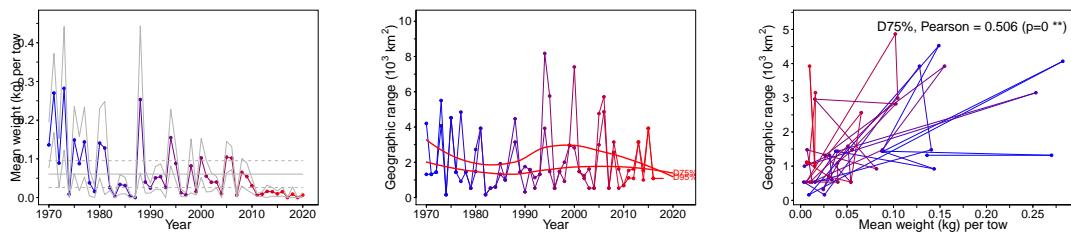


Figure 7.41B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Lumpfish.

986 **7.42 Atlantic spiny lumpsucker (Petite poule de mer atlantique) - species code 502**
 987 (**category LI**)

988 Scientific name: [Eumicrotremus spinosus](#)

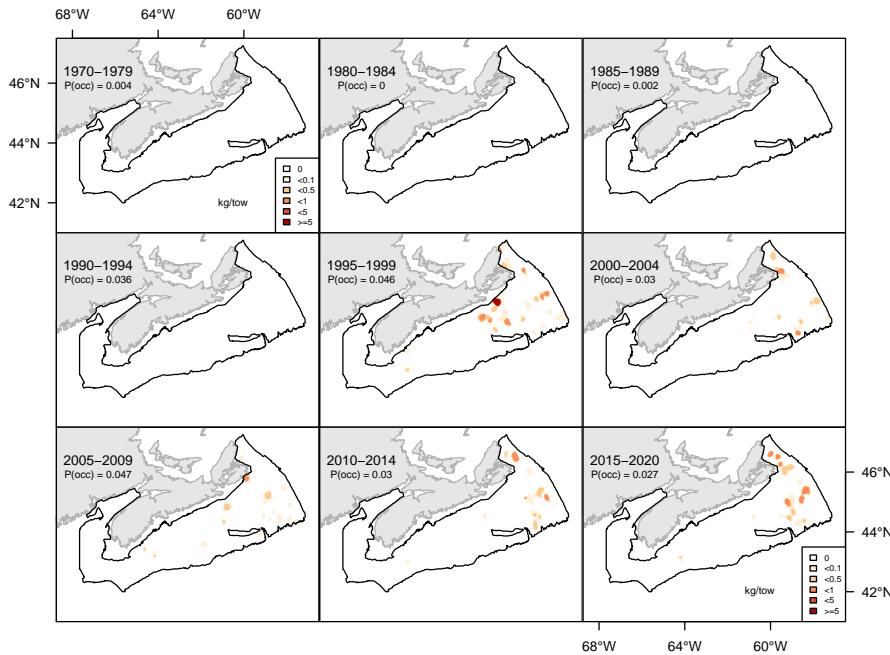


Figure 7.42A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic spiny lumpsucker.

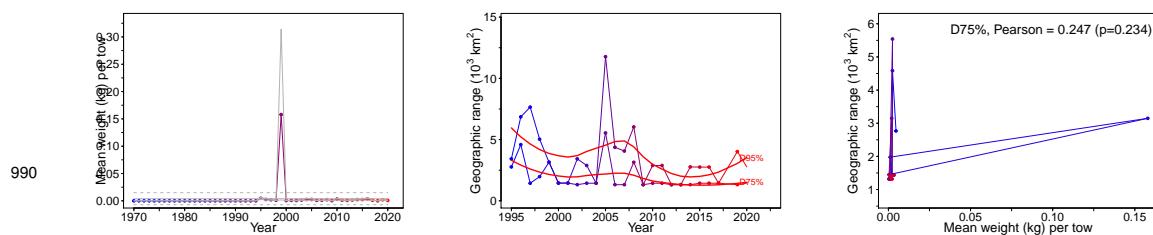


Figure 7.42B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic spiny lumpsucker.

991

7.43 Sand lance (Lançon) - species code 610 (category LI)

992

Scientific name: [Ammodytes dubius](#)

993

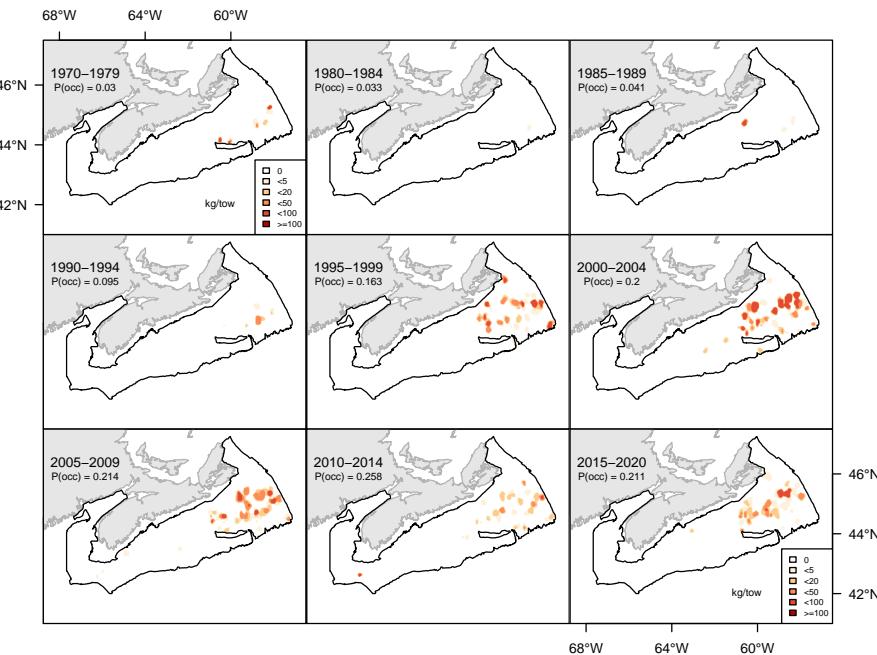


Figure 7.43A. Inverse distance weighted distribution of catch biomass (kg/tow) for Sand lance.

994

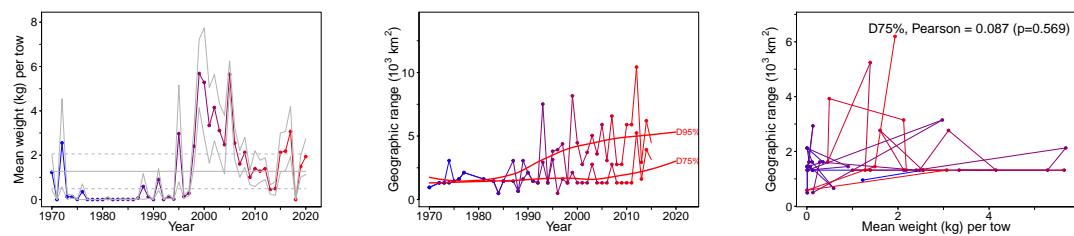


Figure 7.43B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sand lance.

995

7.44 Snakeblenny (Lompénie-serpent) - species code 622 (category LI)

996

Scientific name: [Lumpenus lampretaeformis](#)

997

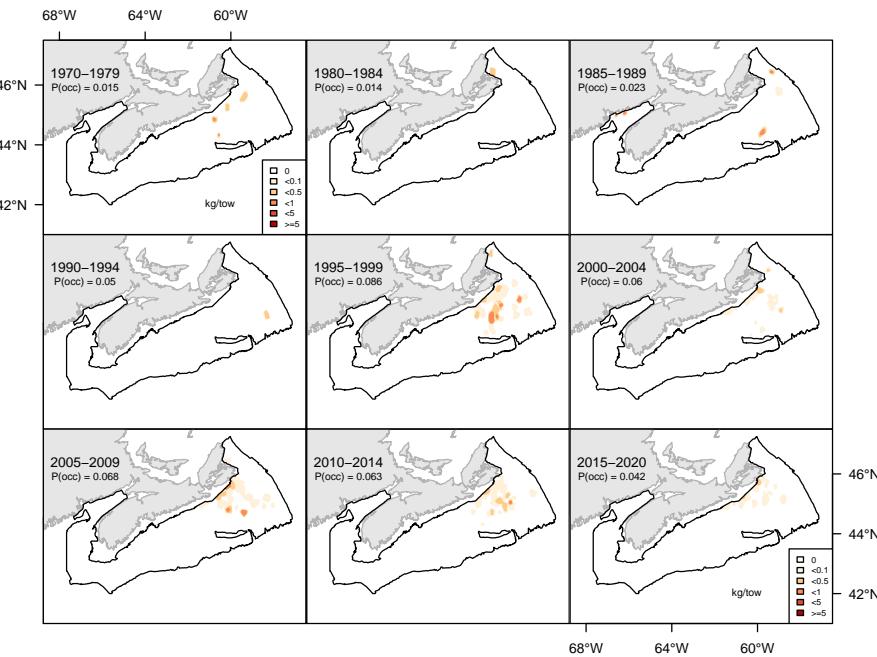


Figure 7.44A. Inverse distance weighted distribution of catch biomass (kg/tow) for Snakeblenny.

998

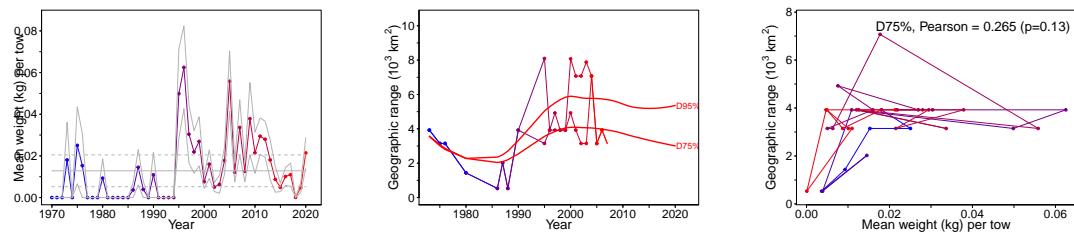


Figure 7.44B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Snakeblenny.

999

7.45 Daubed shanny (Lompénie tachetée) - species code 623 (category LI)

1000

Scientific name: [Leptoclinus maculatus](#)

1001

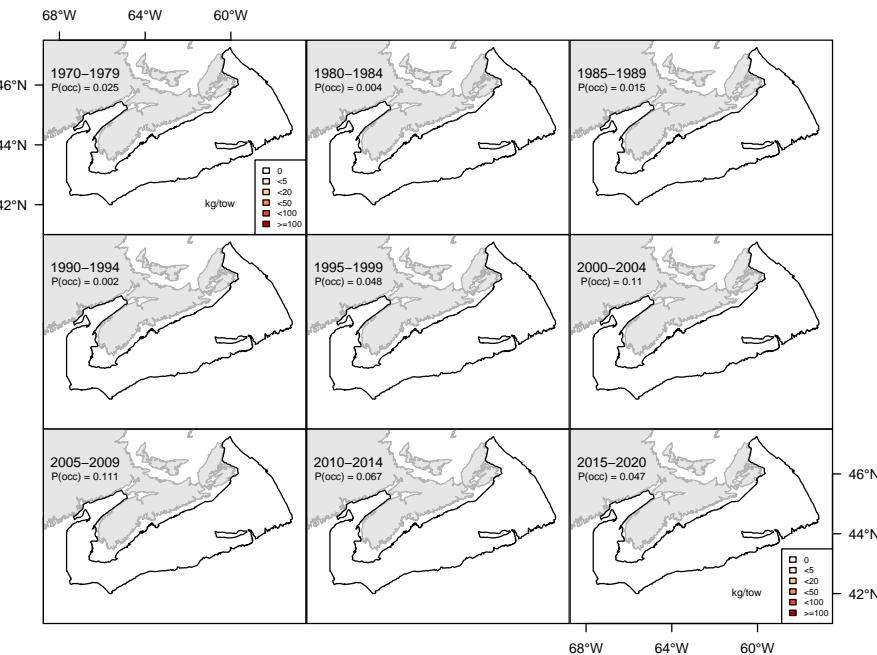


Figure 7.45A. Inverse distance weighted distribution of catch biomass (kg/tow) for Daubed shanny.

1002

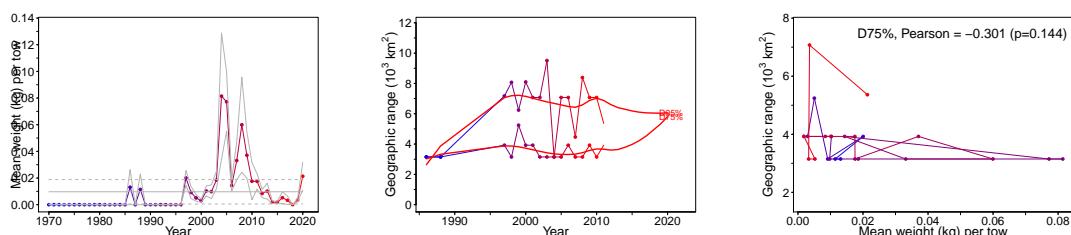


Figure 7.45B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Daubed shanny.

1003

7.46 Vahl's eelpout (*Lycodes vahlii*) - species code 647 (category LI)

1004

Scientific name: [Lycodes vahlii](#)

1005

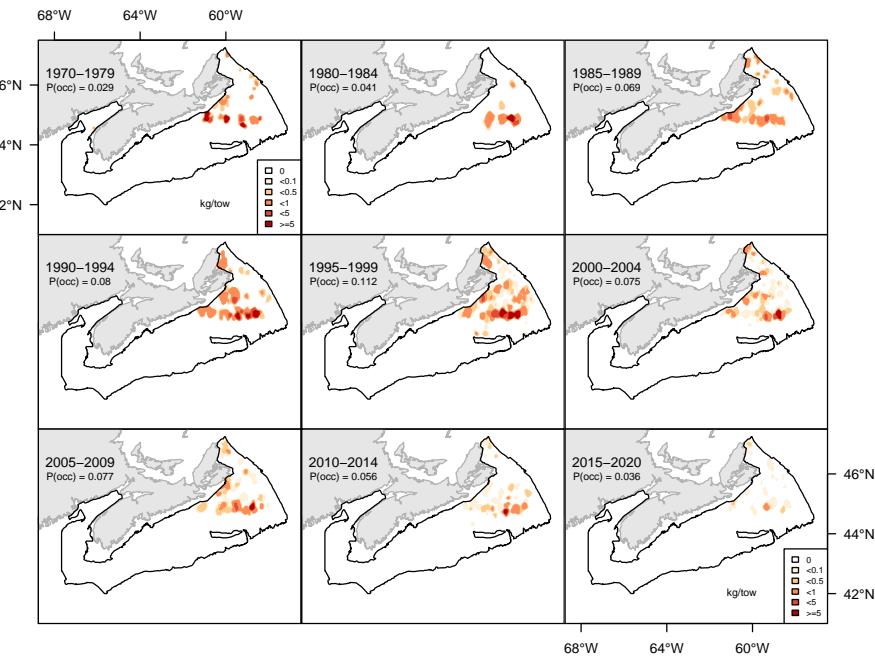


Figure 7.46A. Inverse distance weighted distribution of catch biomass (kg/tow) for Vahl's eelpout.

1006

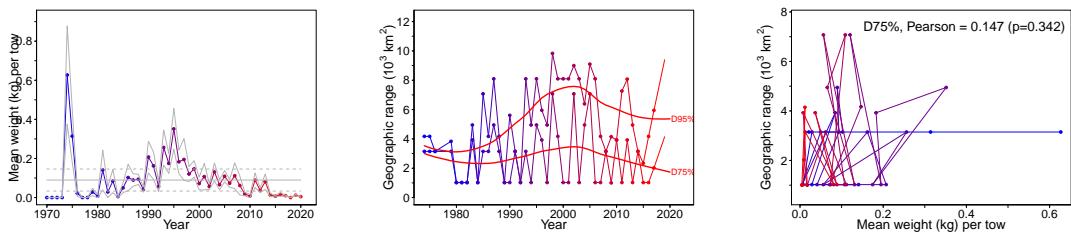


Figure 7.46B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Vahl's eelpout.

1007

7.47 Atlantic butterfish (*Stromaté fossette*) - species code 701 (category LI)

1008

Scientific name: [Peprilus triacanthus](#)

1009

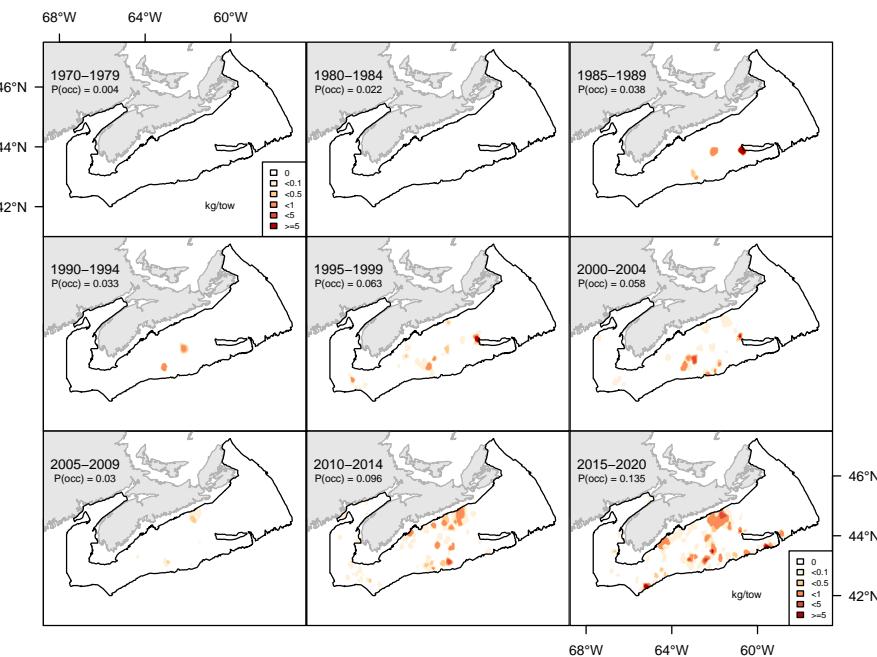


Figure 7.47A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic butterfish.

1010

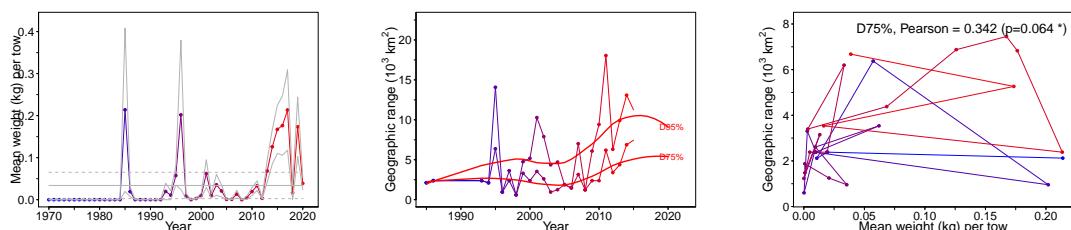


Figure 7.47B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic butterfish.

1011

7.48 Atlantic hookear sculpin (*Hameçon atlantique*) - species code 880 (category LI)

1012

Scientific name: [Artediellus atlanticus](#)

1013

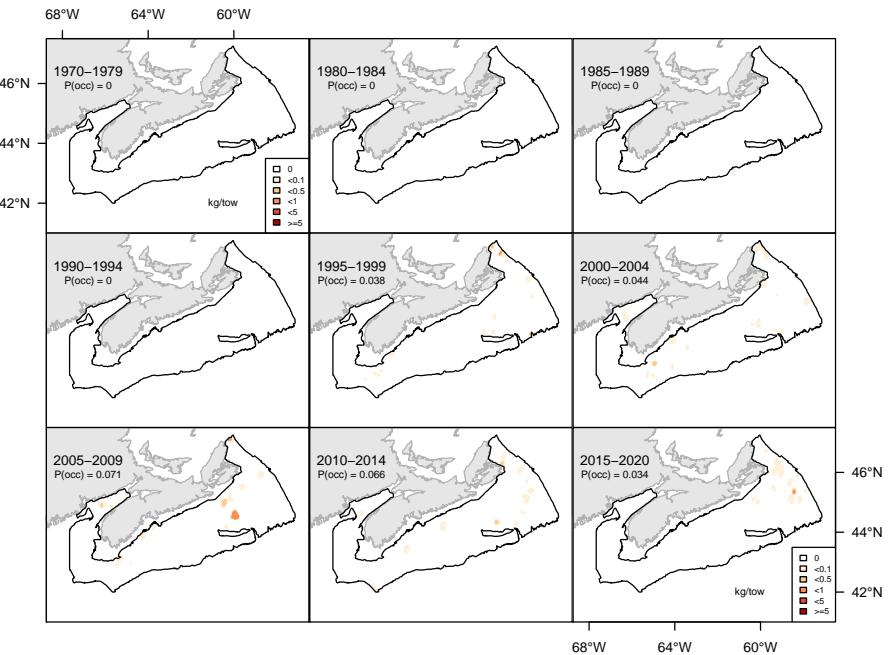


Figure 7.48A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic hookear sculpin.

1014

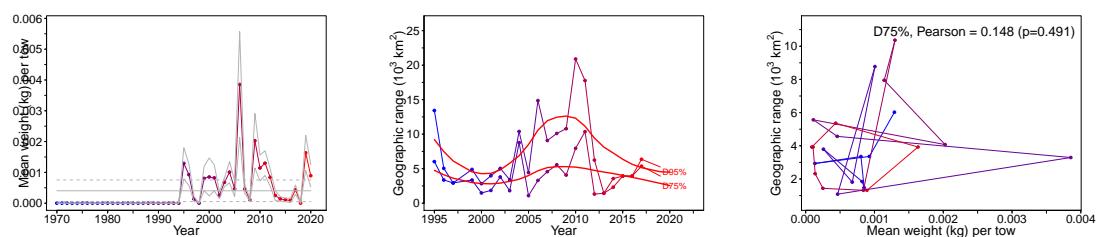


Figure 7.48B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hookear sculpin.

1015

7.49 Barndoor skate (Grande raie) - species code 200 (category LI)

1016

Scientific name: [Dipturus laevis](#)

1017

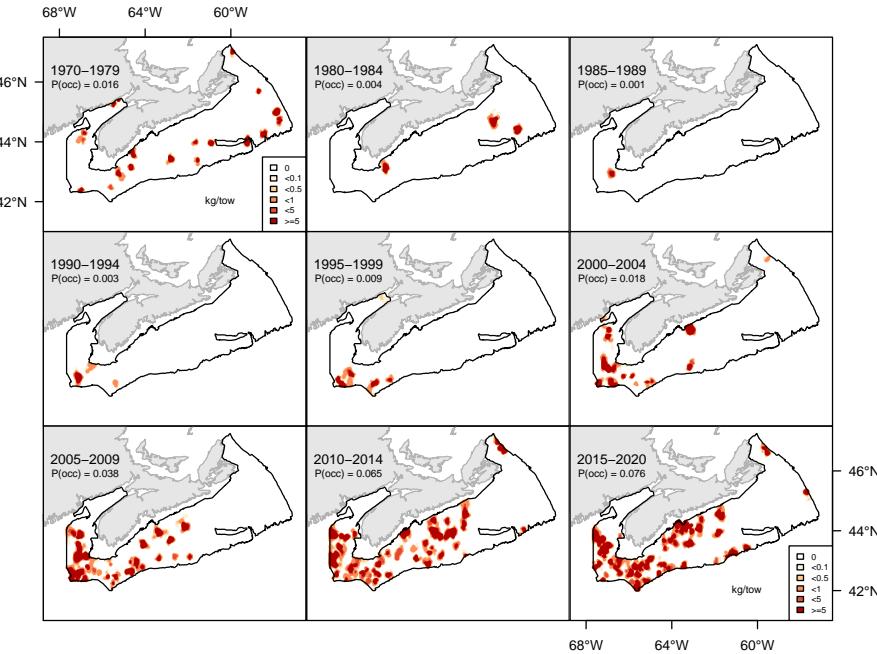


Figure 7.49A. Inverse distance weighted distribution of catch biomass (kg/tow) for Barndoor skate.

1018

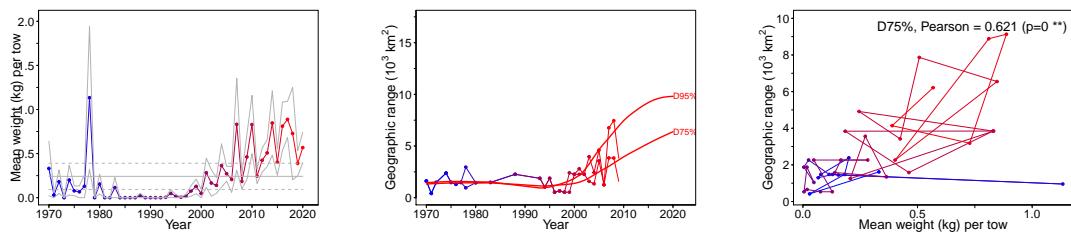


Figure 7.49B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Barndoor skate.

1019

7.50 Little skate (Raie hérisson) - species code 203 (category LI)

1020

Scientific name: [Leucoraja erinacea](#)

1021

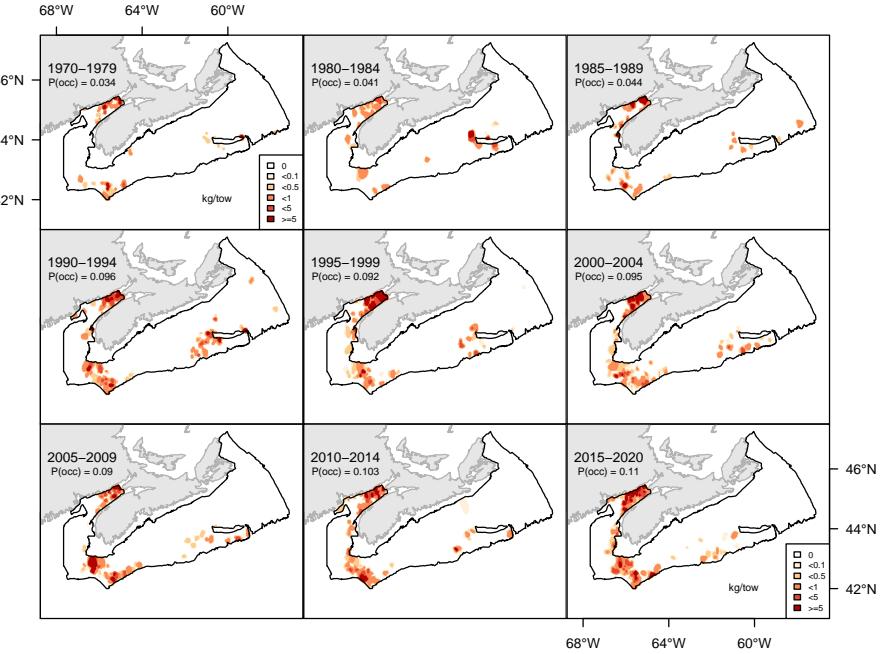


Figure 7.50A. Inverse distance weighted distribution of catch biomass (kg/tow) for Little skate.

1022

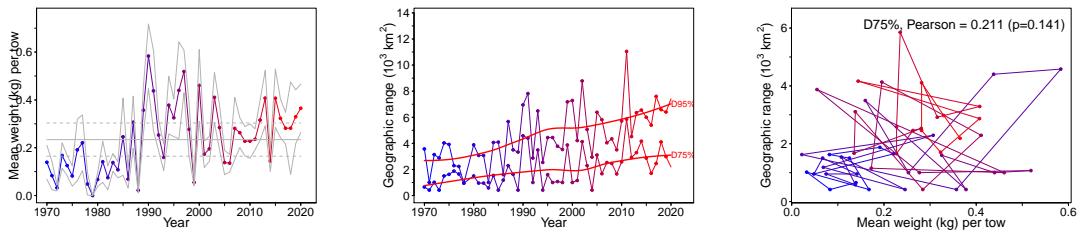


Figure 7.50B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Little skate.

1023

7.51 Northern prawn (Crevette nordique) - species code 2211 (category SF)

1024

Scientific name: [Pandalus borealis](#)

1025

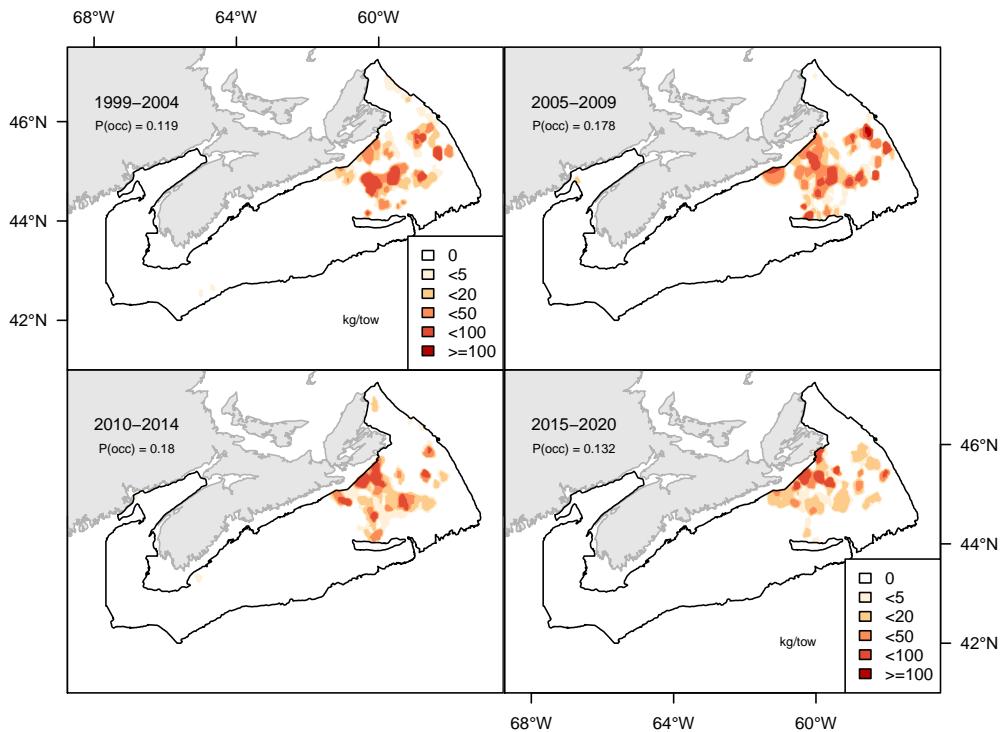


Figure 7.51A. Inverse distance weighted distribution of catch biomass (kg/tow) for Northern prawn.

1026

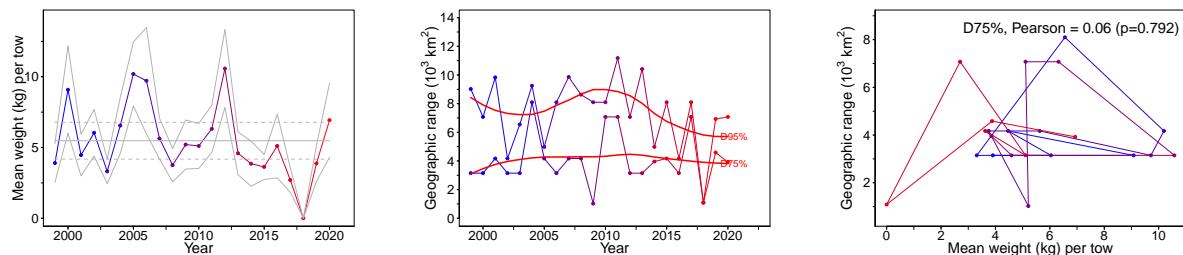


Figure 7.51B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Northern prawn.

1027

7.52 Jonah crab (Tourteau jona) - species code 2511 (category SF)

1028

Scientific name: [Cancer borealis](#)

1029

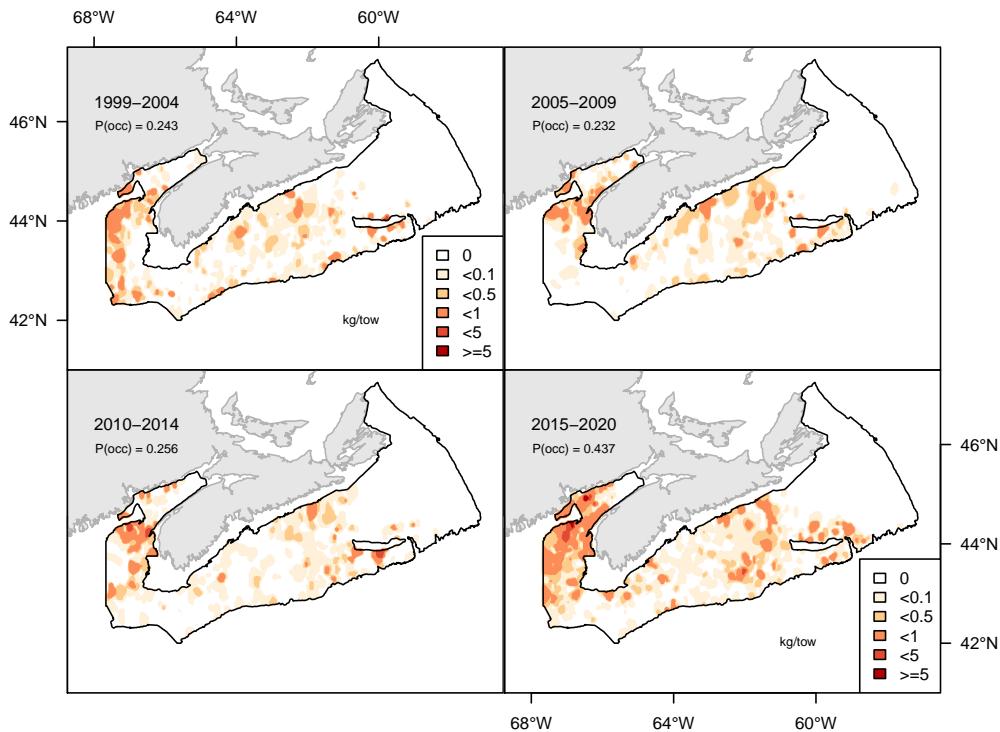


Figure 7.52A. Inverse distance weighted distribution of catch biomass (kg/tow) for Jonah crab.

1030

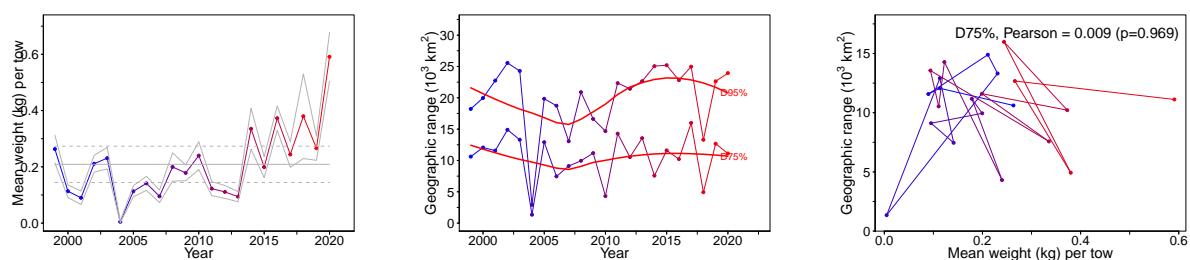


Figure 7.52B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Jonah crab.

1031

7.53 Atlantic rock crab (Tourteau poïnclos) - species code 2513 (category SF)

1032

Scientific name: [Cancer irroratus](#)

1033

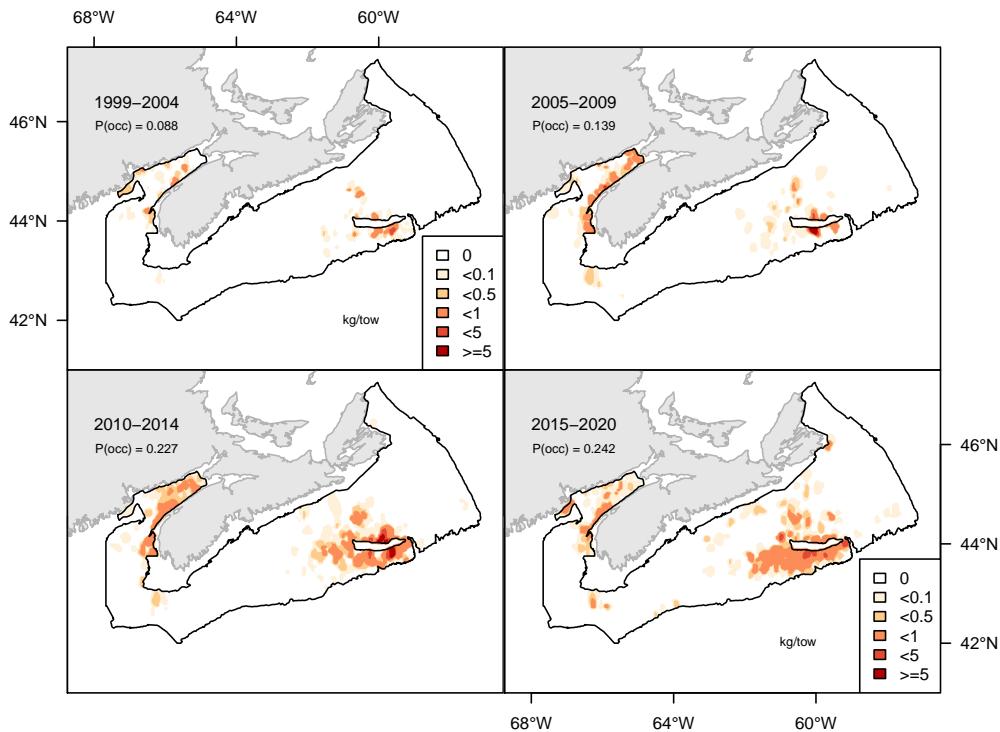


Figure 7.53A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic rock crab.

1034

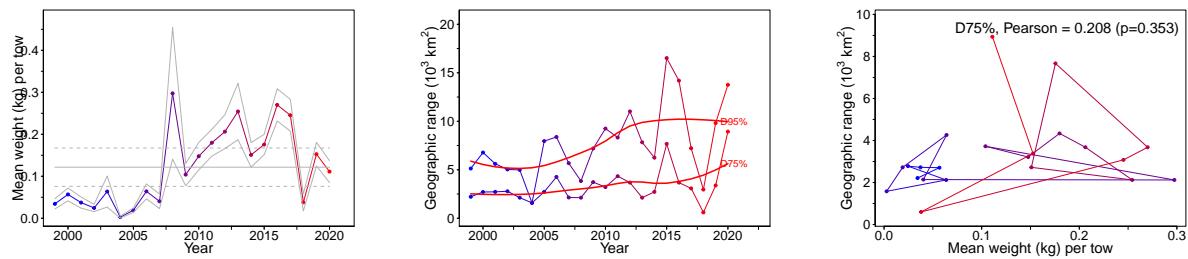


Figure 7.53B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic rock crab.

1035 **7.54 Arctic lyre crab (*Crabe Hyas coarctatus*) - species code 2521 (category SF)**

1036 Scientific name: [Hyas coarctatus](#)

1037

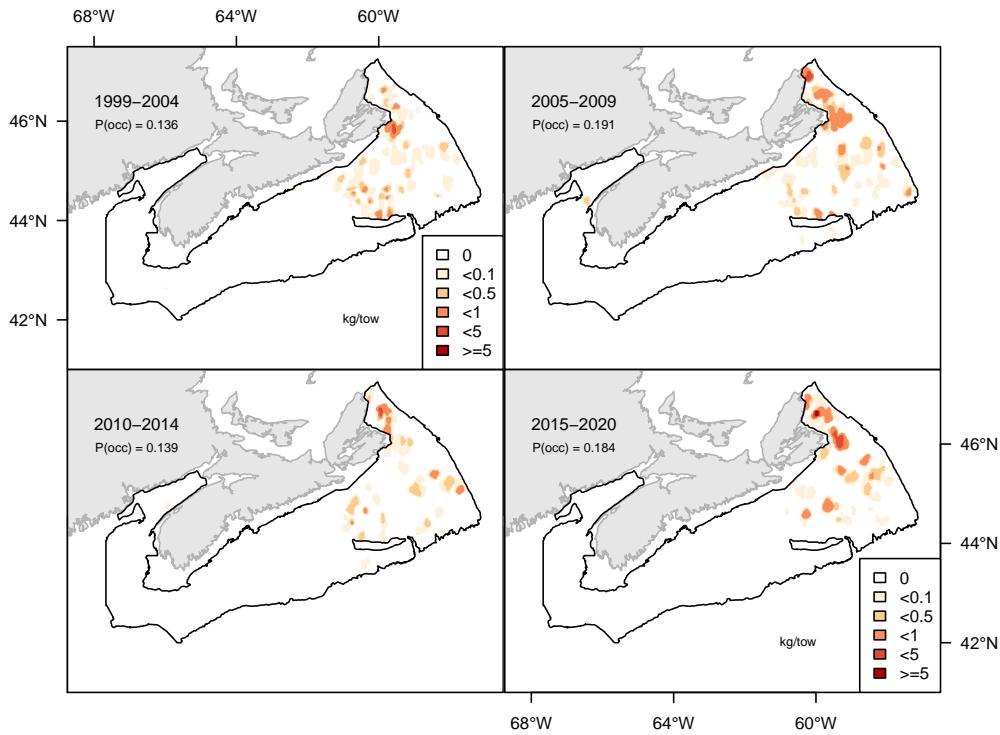


Figure 7.54A. Inverse distance weighted distribution of catch biomass (kg/tow) for Arctic lyre crab.

1038

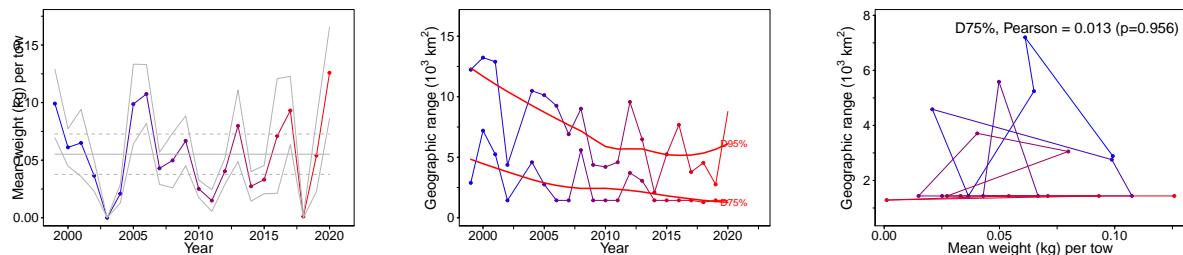


Figure 7.54B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic lyre crab.

1039

7.55 Atlantic king crab (Crabe épineux du nord) - species code 2523 (category SF)

1040

Scientific name: [Lithodes maja](#)

1041

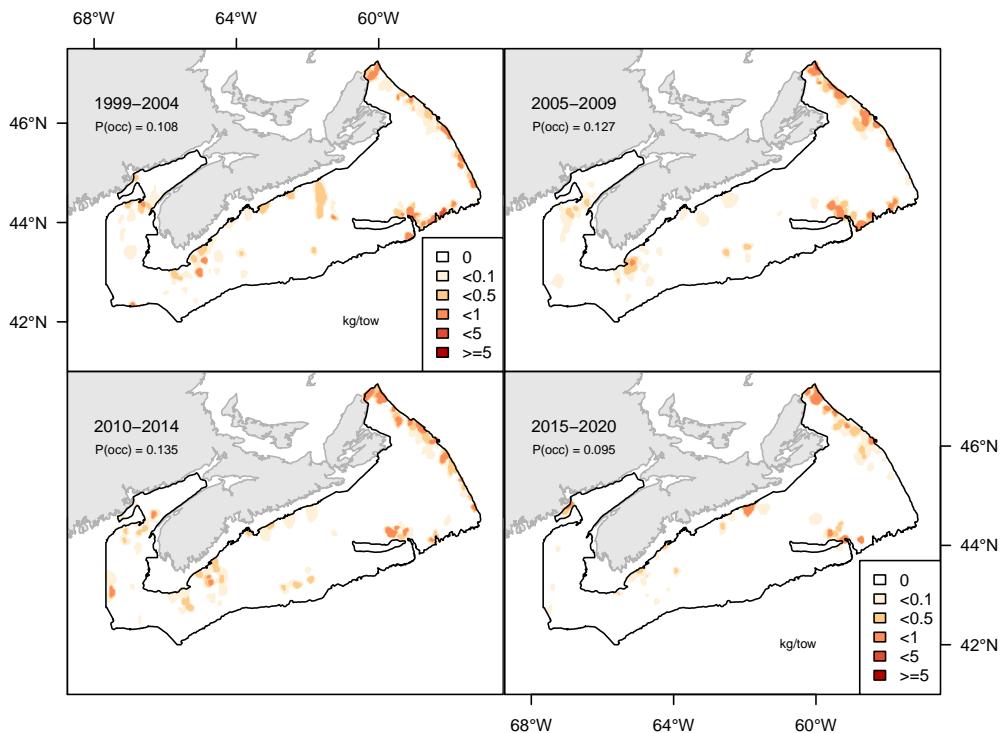


Figure 7.55A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic king crab.

1042

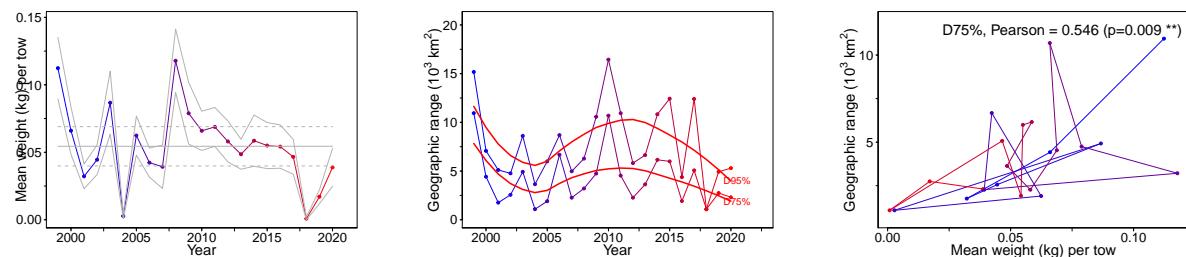


Figure 7.55B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic king crab.

1043

7.56 Queen crab (Crabe des neiges) - species code 2526 (category SF)

1044

Scientific name: [Chionoecetes opilio](#)

1045

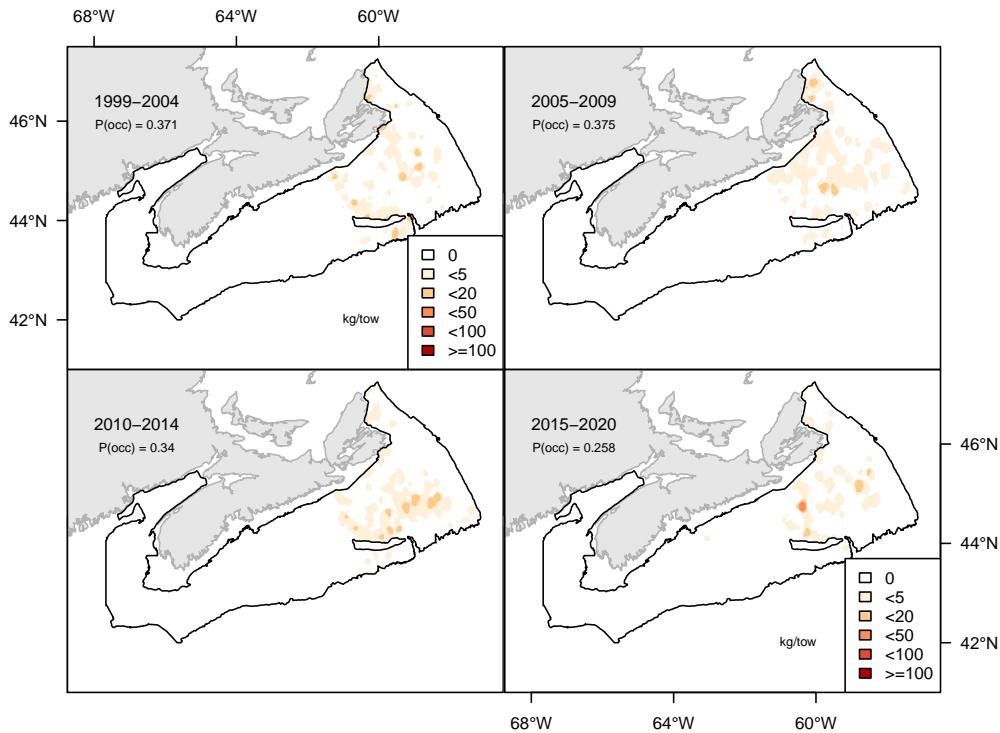


Figure 7.56A. Inverse distance weighted distribution of catch biomass (kg/tow) for Queen crab.

1046

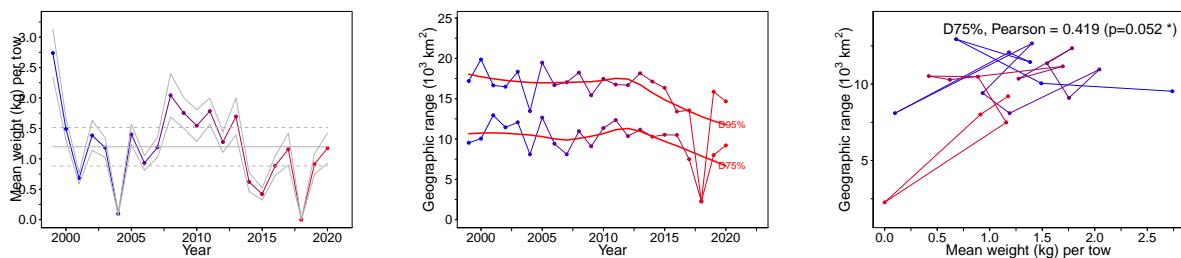


Figure 7.56B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Queen crab.

1047

7.57 Great spider crab (Crabe lyre araignée) - species code 2527 (category SF)

1048

Scientific name: [Hyas araneus](#)

1049

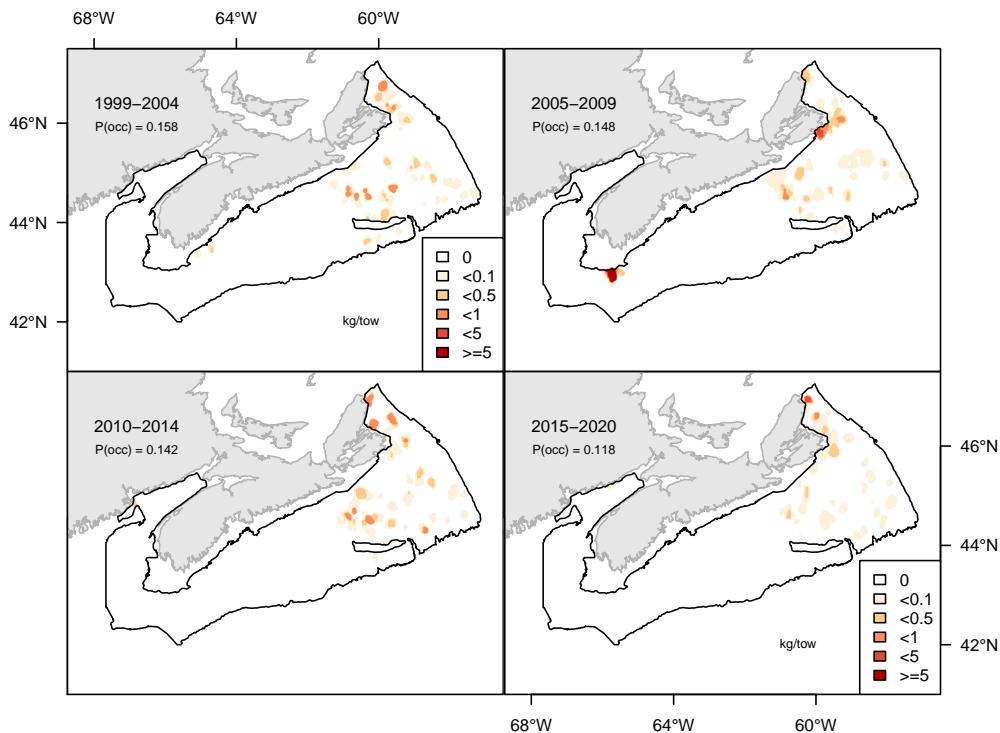


Figure 7.57A. Inverse distance weighted distribution of catch biomass (kg/tow) for Great spider crab.

1050

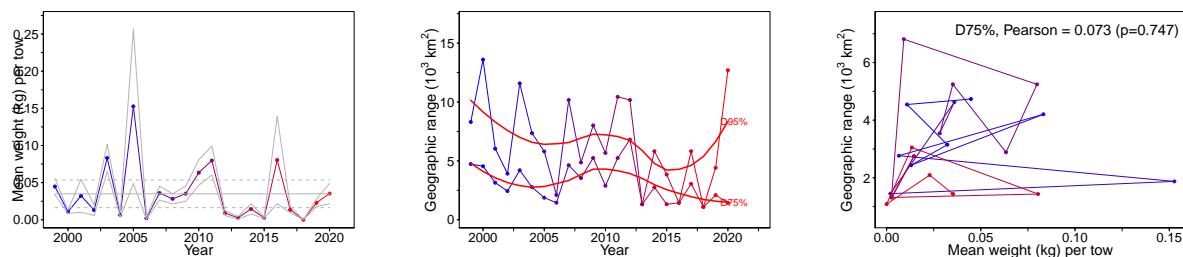


Figure 7.57B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Great spider crab.

1051

7.58 American lobster (Homard américain) - species code 2550 (category SF)

1052

Scientific name: [Homarus americanus](#)

1053

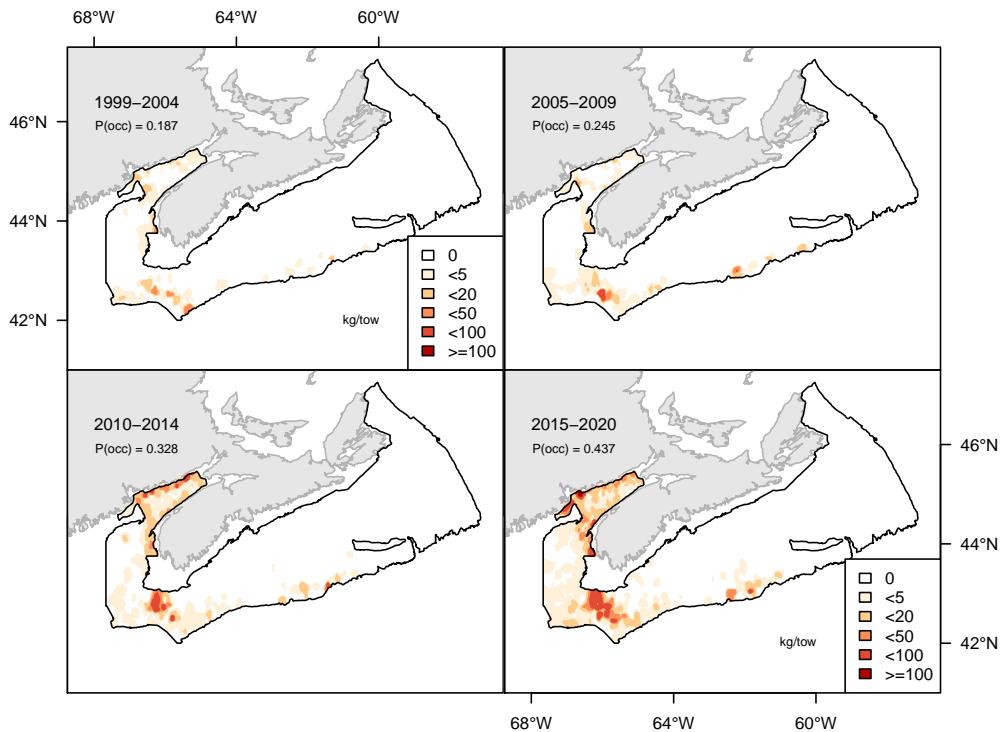


Figure 7.58A. Inverse distance weighted distribution of catch biomass (kg/tow) for American lobster.

1054

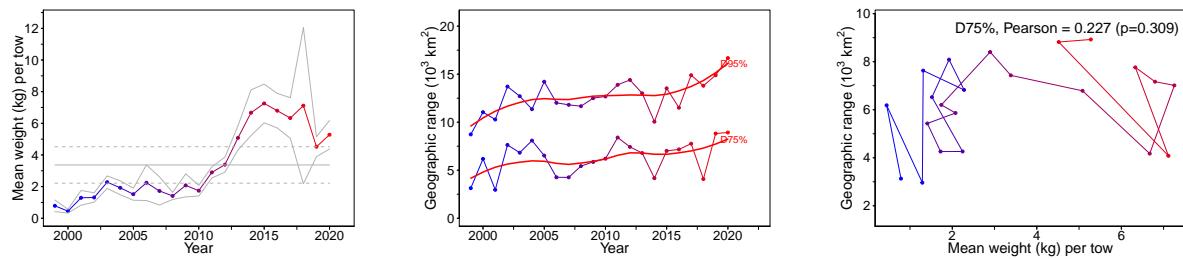


Figure 7.58B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American lobster.

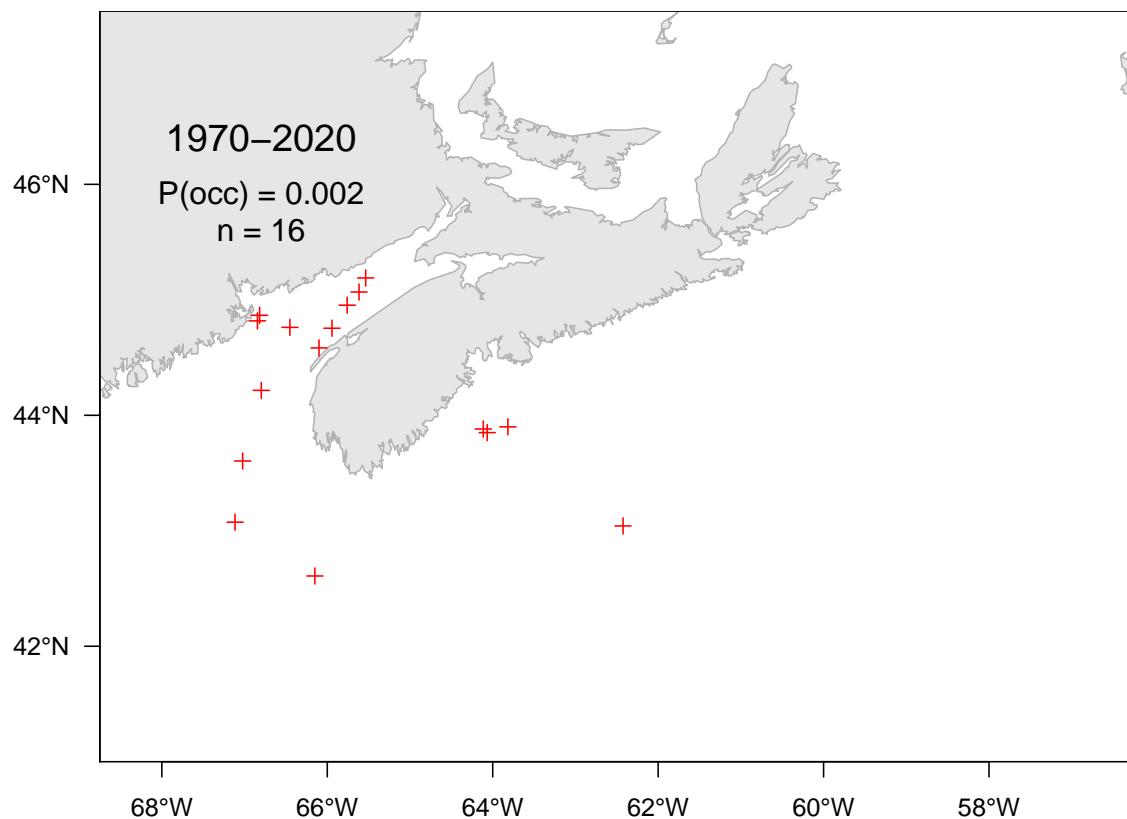
1055

7.59 Sea lamprey (*Lamproie marine*) - species code 240 (category LR)

1056

Scientific name: [Petromyzon marinus](#)

1057



1058

7.60 Atlantic tomcod (*Poulamon atlantique*) - species code 17 (category LR)

1059

Scientific name: [Micogadus tomcod](#)

1060

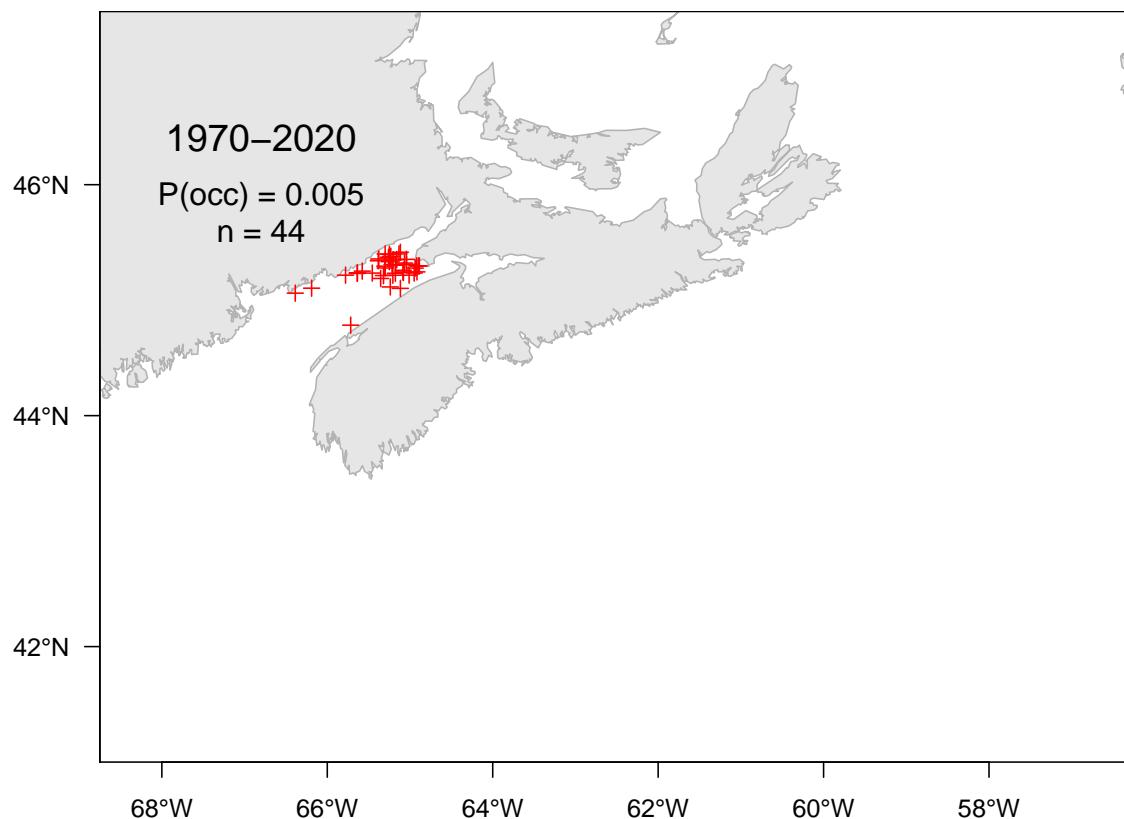


Figure 7.60A. Catch distribution for Atlantic tomcod.

1061

7.61 Offshore silver hake (Merlu argenté du large) - species code 19 (category LR)

1062

Scientific name: [Merluccius albidus](#)

1063

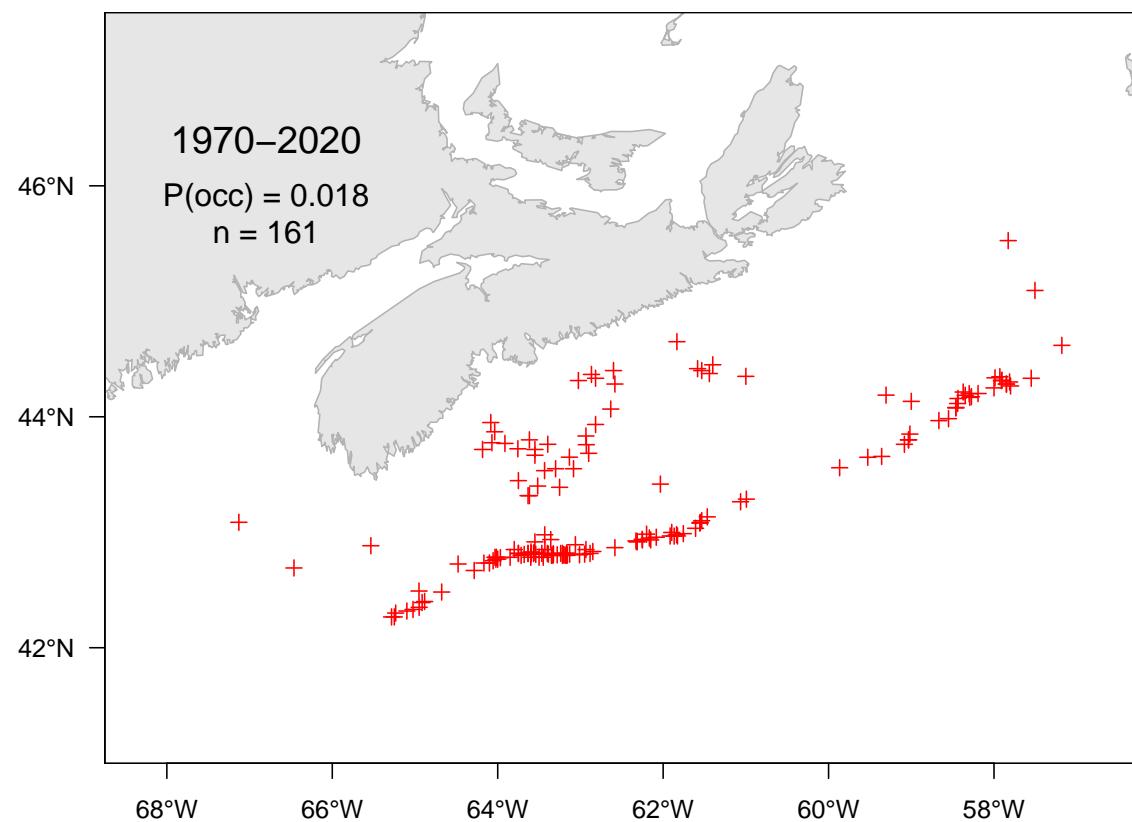


Figure 7.61A. Catch distribution for Offshore silver hake.

1064

7.62 Spotted wolffish (*Loup tacheté*) - species code 51 (category LR)

1065

Scientific name: [Anarhichas minor](#)

1066

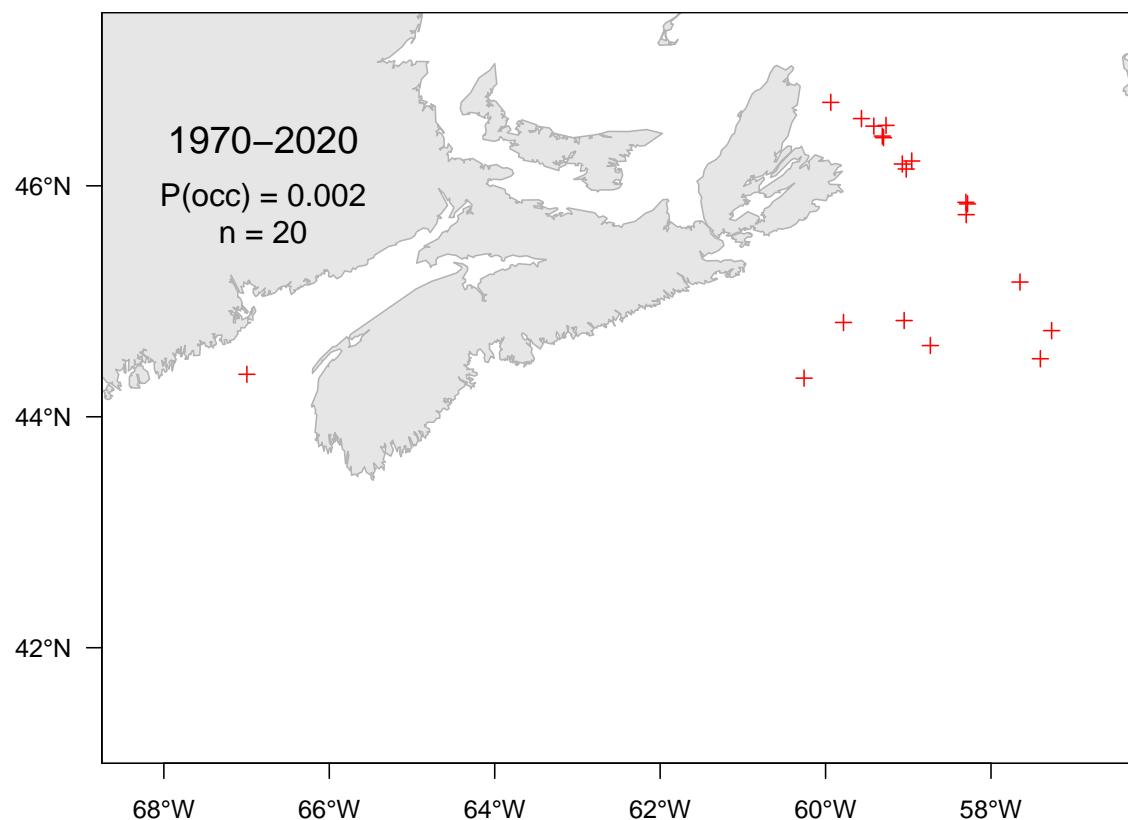


Figure 7.62A. Catch distribution for Spotted wolffish.

1067

7.63 Northern wolffish (Loup à tête large) - species code 52 (category LR)

1068

Scientific name: [Anarhichas denticulatus](#)

1069

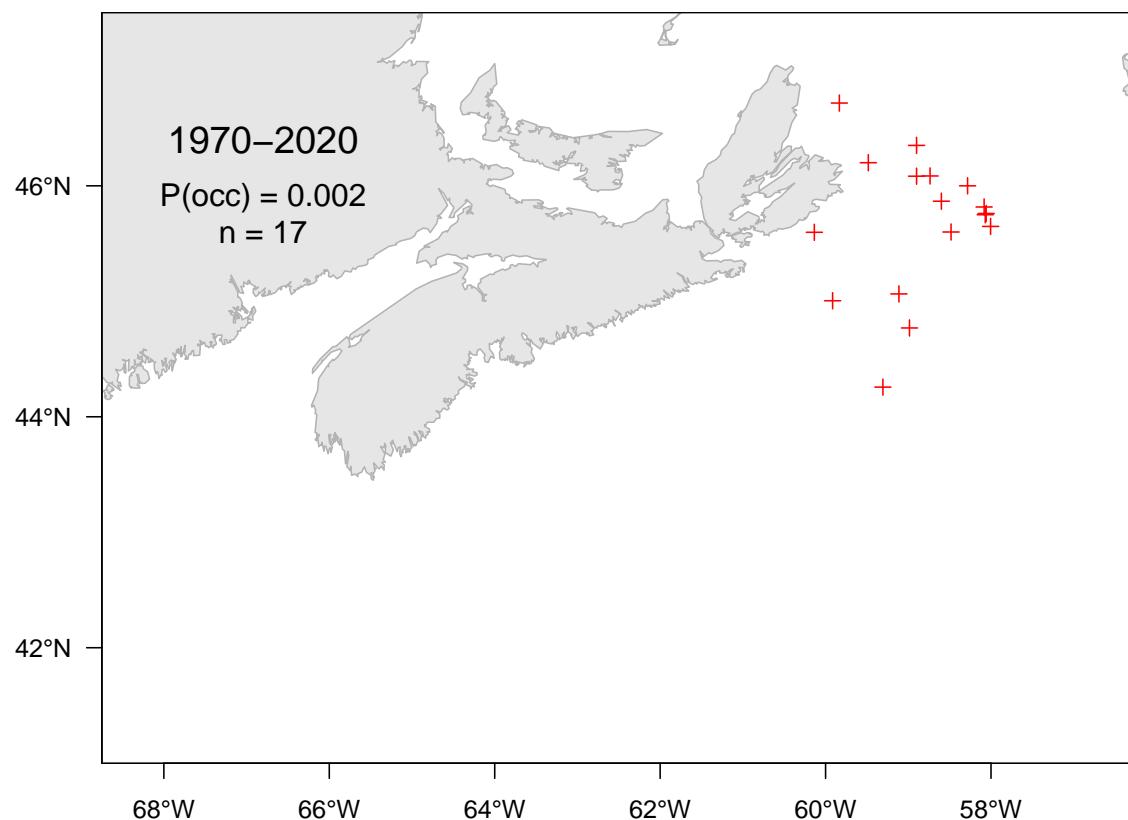


Figure 7.63A. Catch distribution for Northern wolffish.

1070

7.64 Rainbow smelt (Éperlan arc-en-ciel) - species code 63 (category LR)

1071

Scientific name: [Osmerus mordax](#)

1072

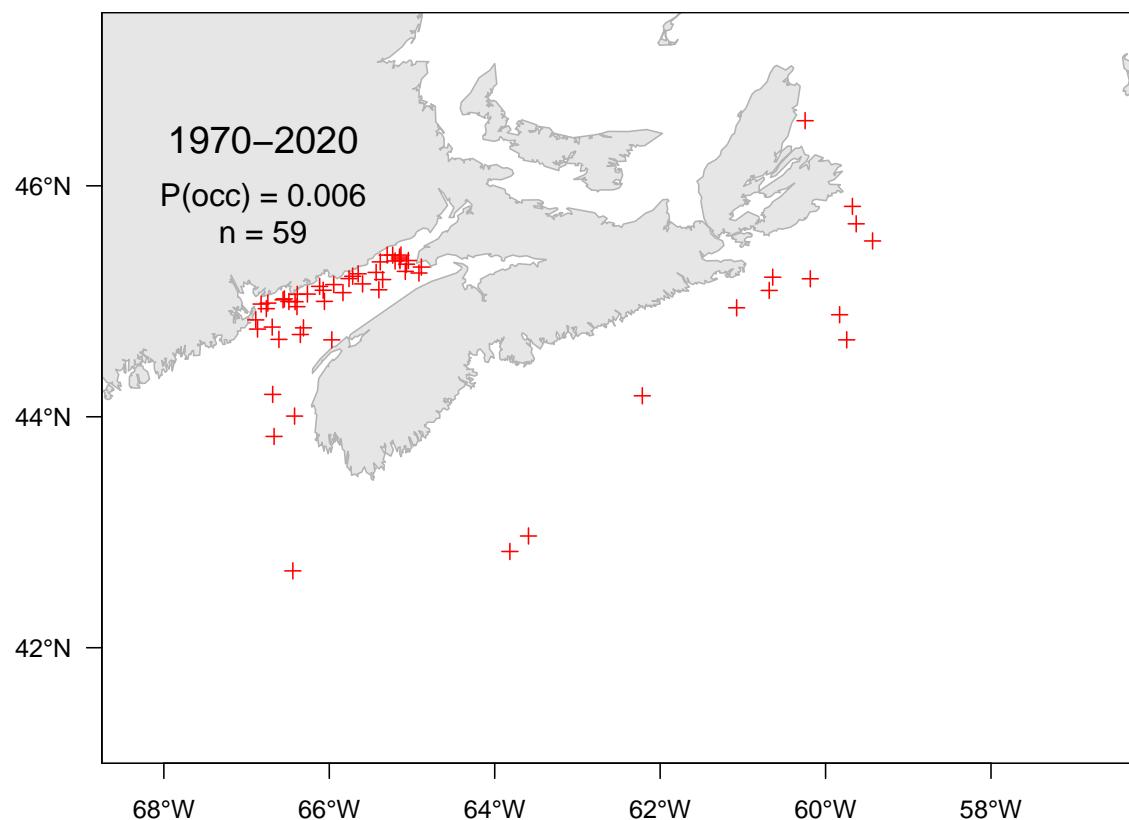


Figure 7.64A. Catch distribution for Rainbow smelt.

1073

7.65 Cunner (Tanche-tautogue) - species code 122 (category LR)

1074

Scientific name: [Tautogolabrus adspersus](#)

1075

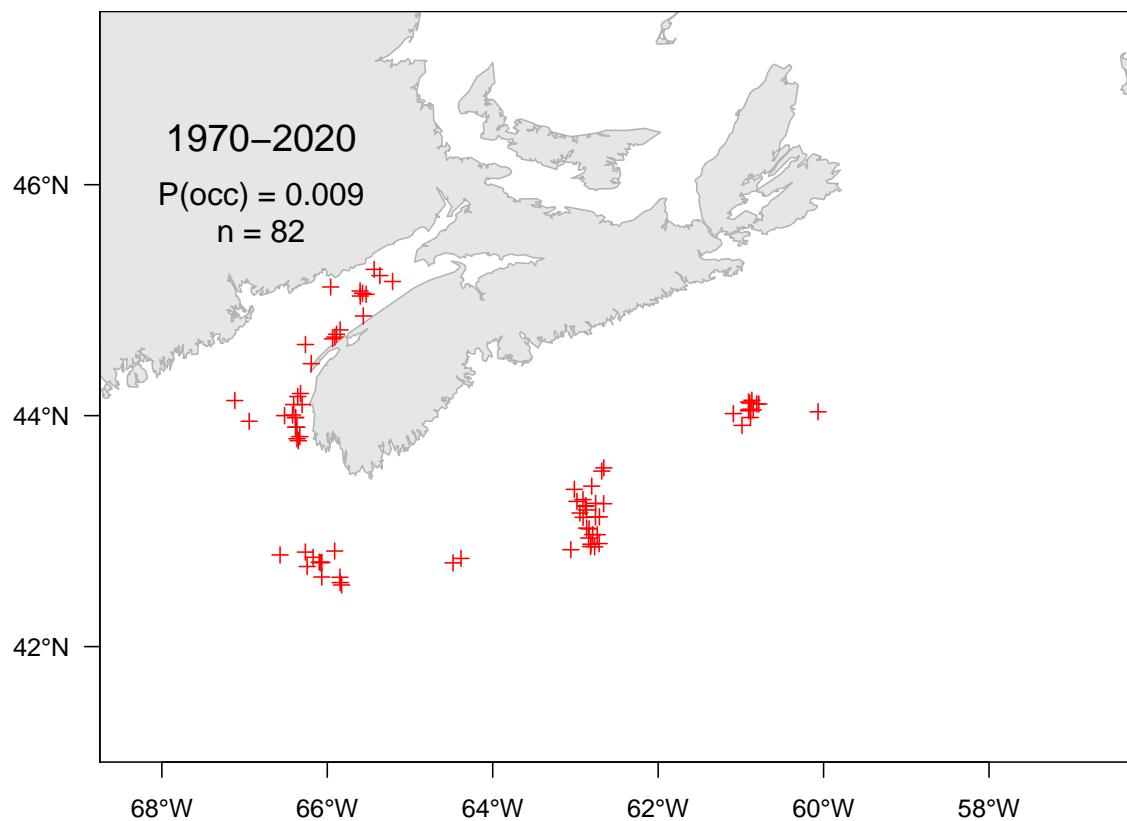


Figure 7.65A. Catch distribution for Cunner.

1076

7.66 Fourspot flounder (Cardeau à quatre ocelles) - species code 142 (category LR)

1077

Scientific name: [Hippoglossina oblonga](#)

1078

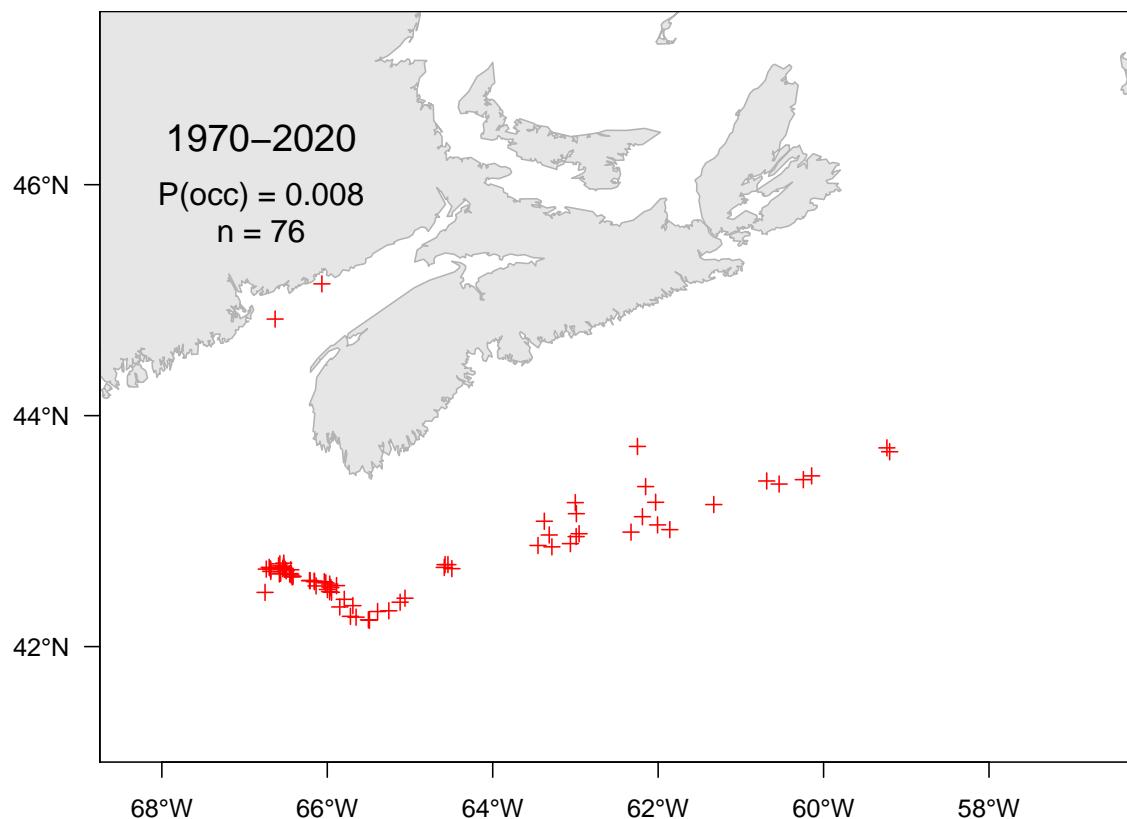


Figure 7.66A. Catch distribution for Fourspot flounder.

1079

7.67 Windowpane flounder (Turbot de sable) - species code 143 (category LR)

1080

Scientific name: [Scophthalmus aquosus](#)

1081

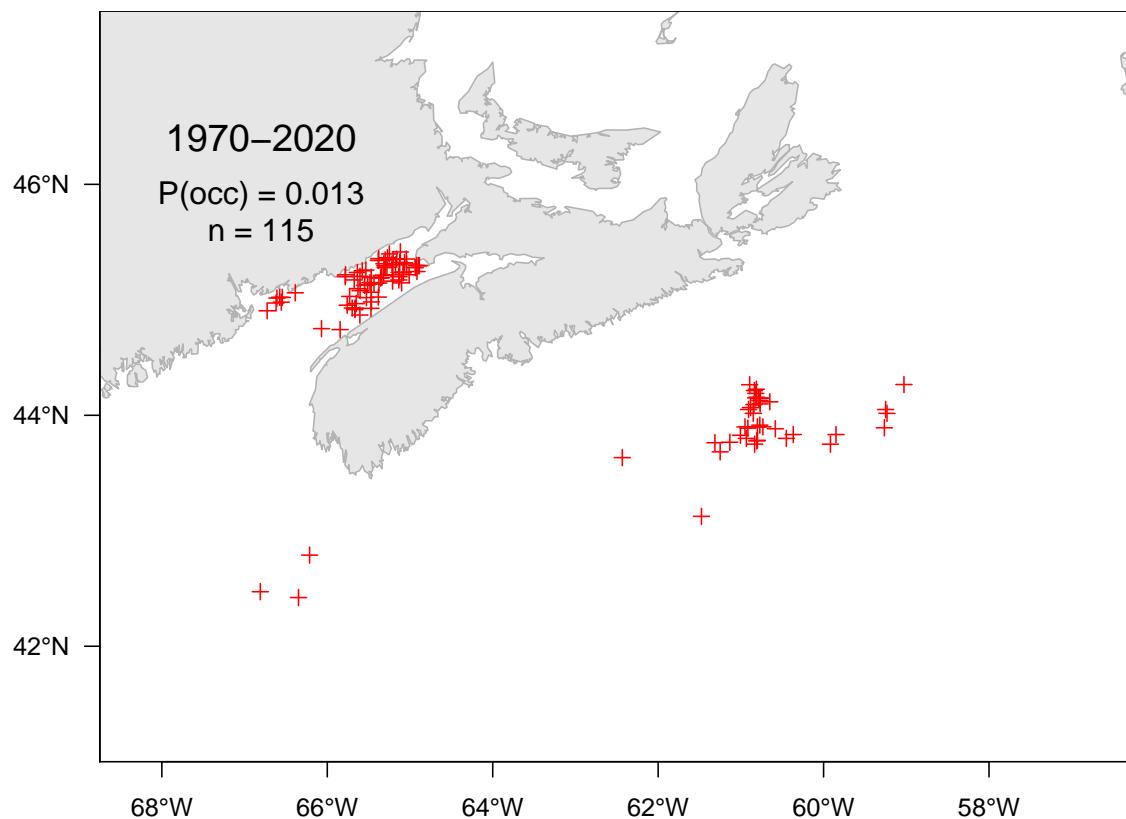


Figure 7.67A. Catch distribution for Windowpane flounder.

1082

7.68 Longnose greeneye (Oeil-vert à long nez) - species code 149 (category LR)

1083

Scientific name: [Parasudis triculenta](#)

1084

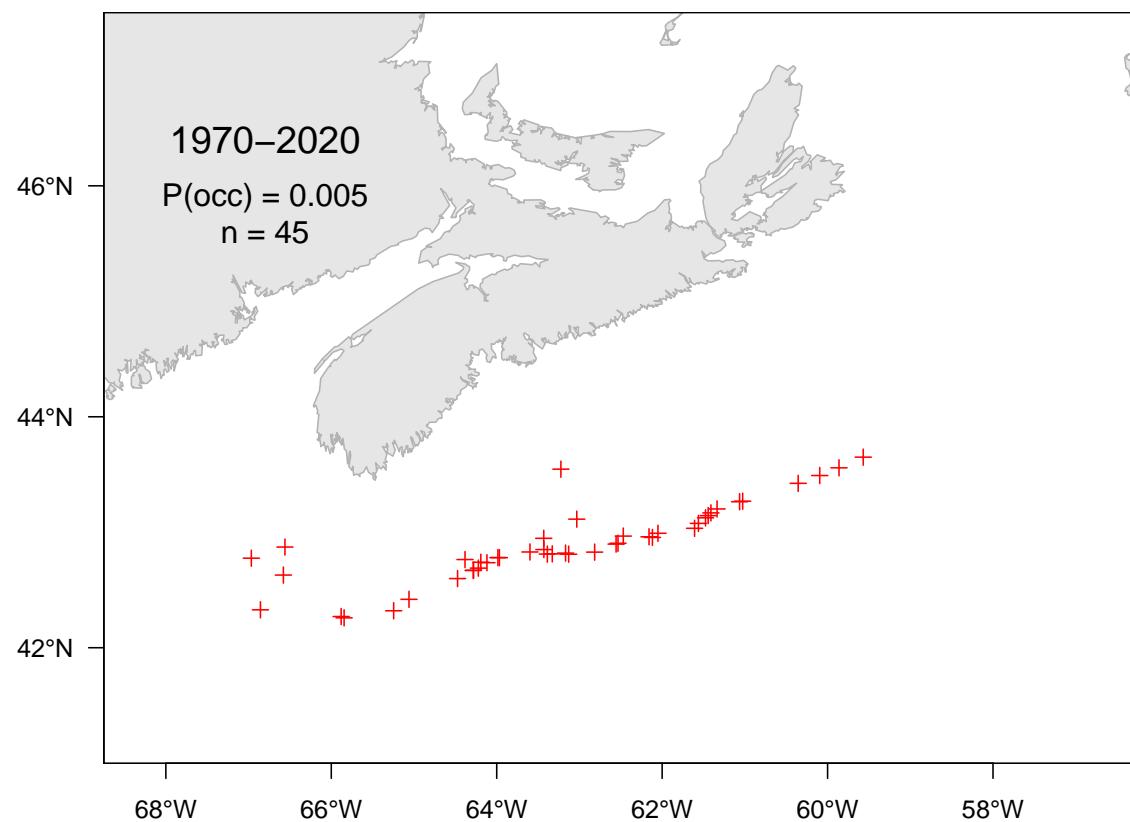


Figure 7.68A. Catch distribution for Longnose greeneye.

1085

7.69 Lanternfishes (Poissons-lanternes) - species code 150 (category LR)

1086

Scientific name: [Myctophidae](#)

1087

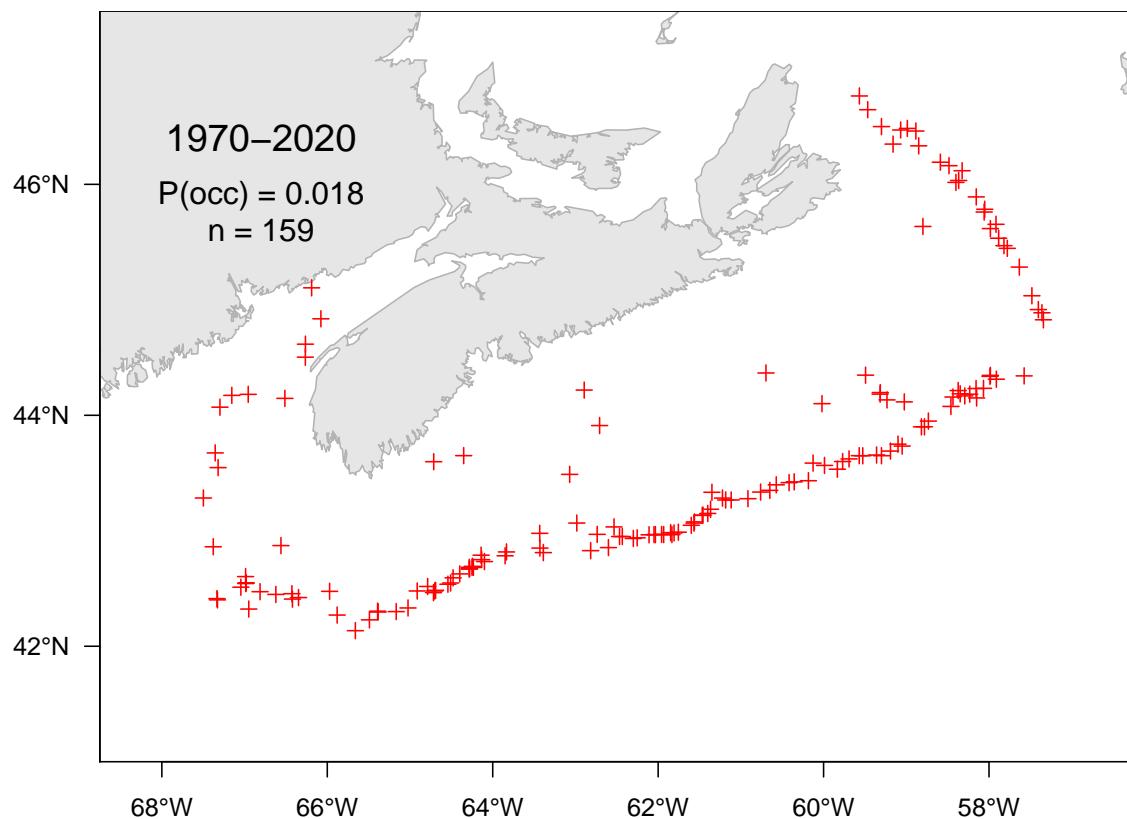


Figure 7.69A. Catch distribution for Lanternfishes.

1088

7.70 Shortnose greeneye (Éperlan du large) - species code 156 (category LR)

1089

Scientific name: [Chlorophthalmus agassizi](#)

1090

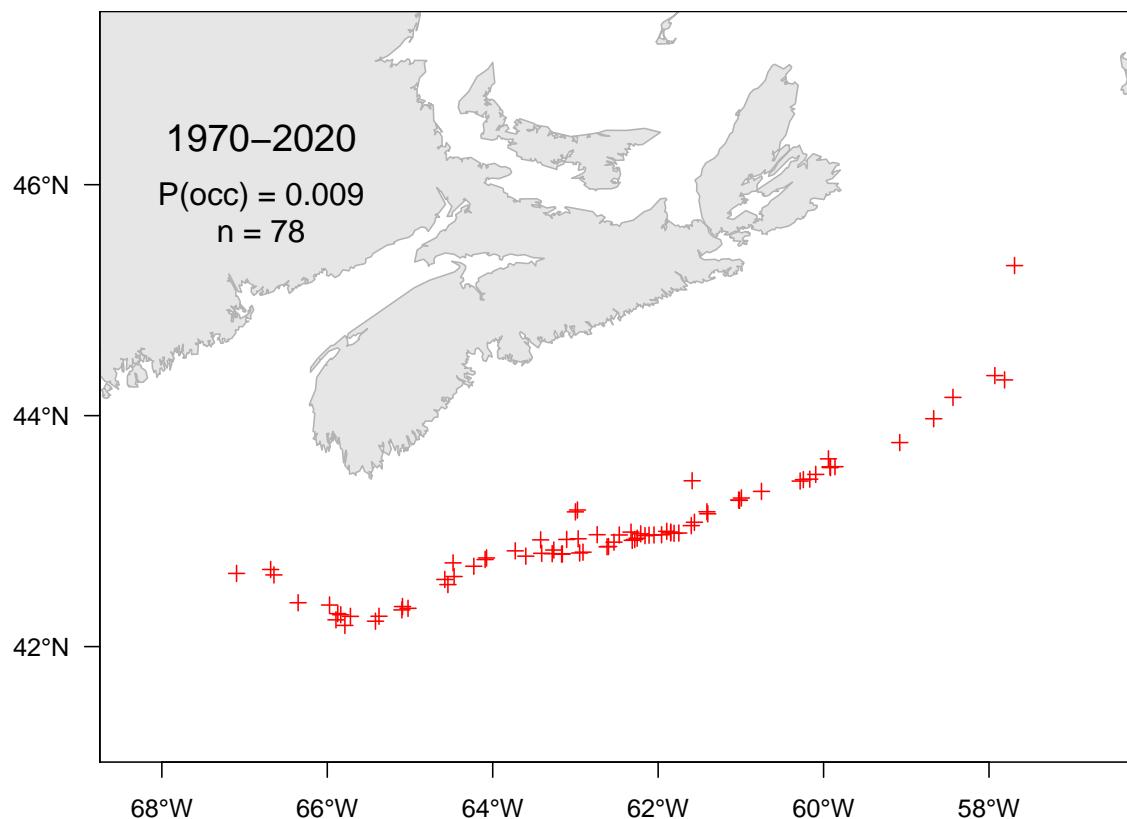


Figure 7.70A. Catch distribution for Shortnose greeneye.

1091

7.71 Silvery lightfish (Brossé améthyste) - species code 158 (category LR)

1092

Scientific name: [Maurolicus muelleri](#)

1093

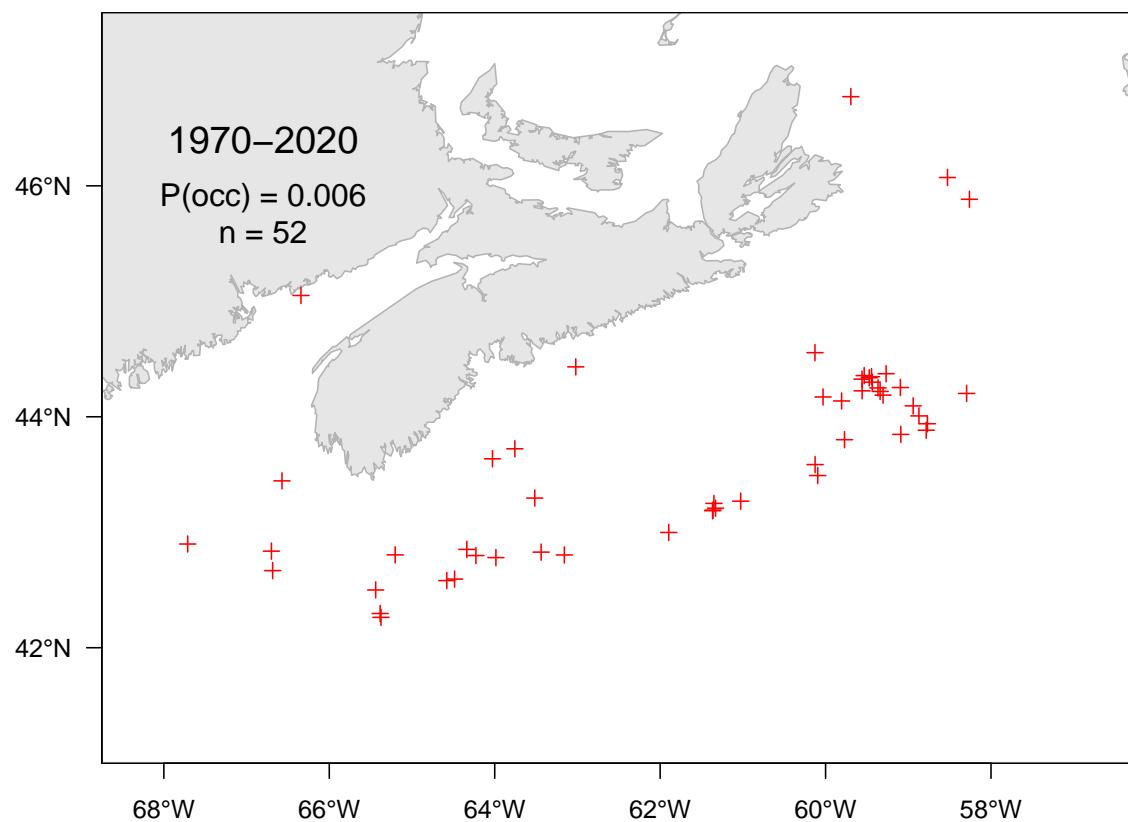


Figure 7.71A. Catch distribution for Silvery lightfish.

1094

7.72 Boa dragonfish (Dragon-boa) - species code 159 (category LR)

1095

Scientific name: [Stomias boa](#)

1096

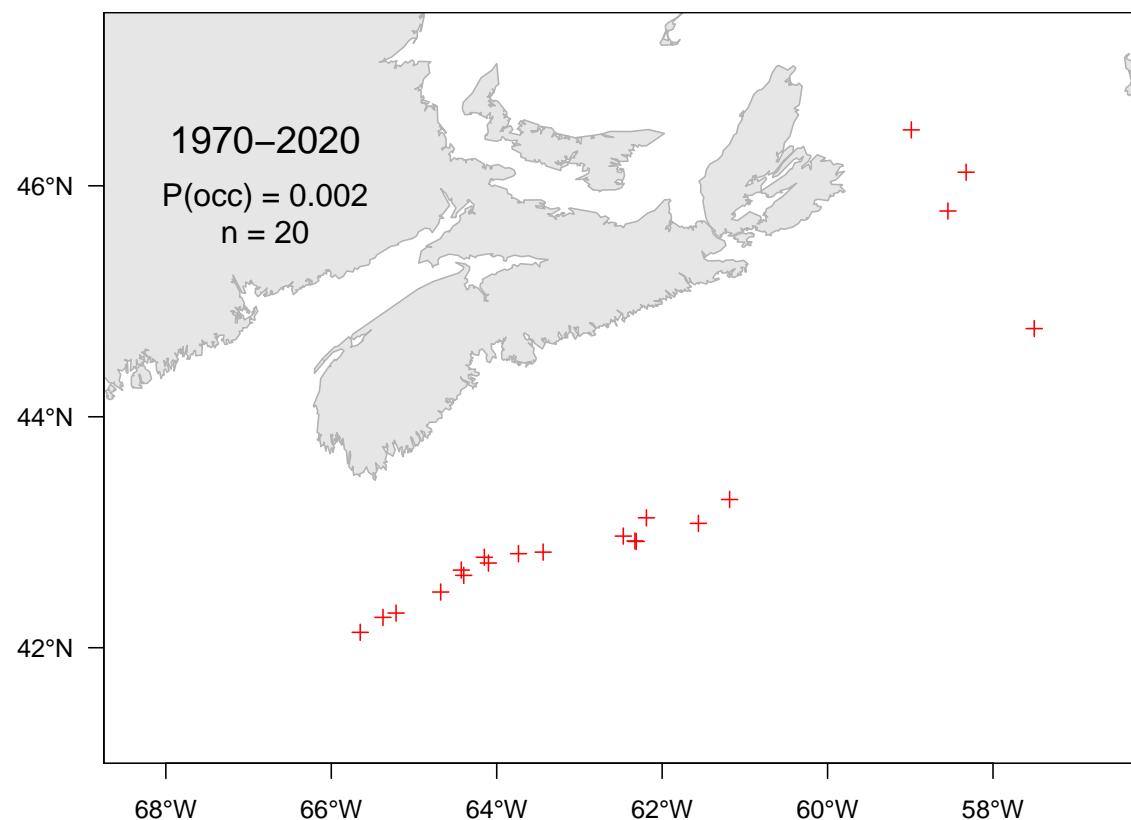


Figure 7.72A. Catch distribution for Boa dragonfish.

1097 **7.73 Shorthorn sculpin (Chabosseau à épines courtes) - species code 301 (category**
1098 **LR)**

1099 Scientific name: [Myoxocephalus scorpius](#)

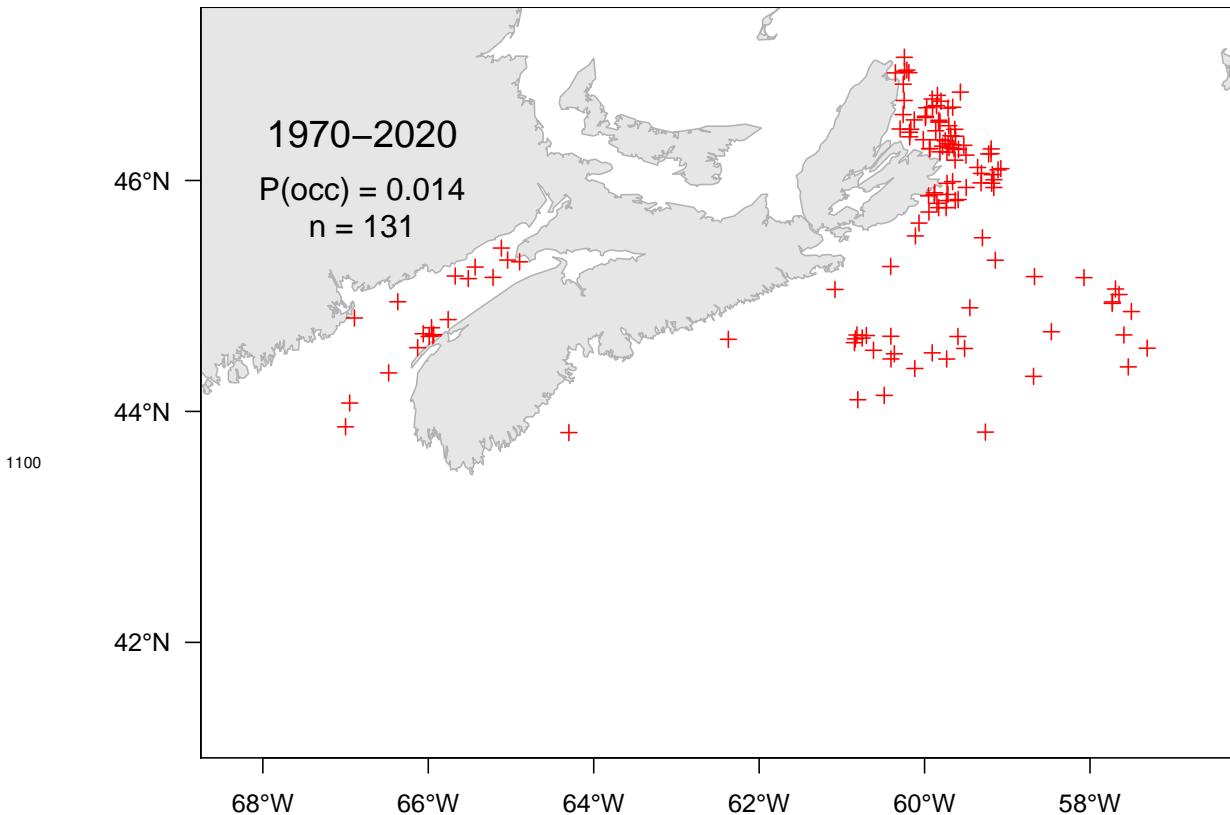


Figure 7.73A. Catch distribution for Shorthorn sculpin.

1101

7.74 Grubby (Chabosseau bronzé) - species code 303 (category LR)

1102

Scientific name: [Myoxocephalus aenaeus](#)

1103

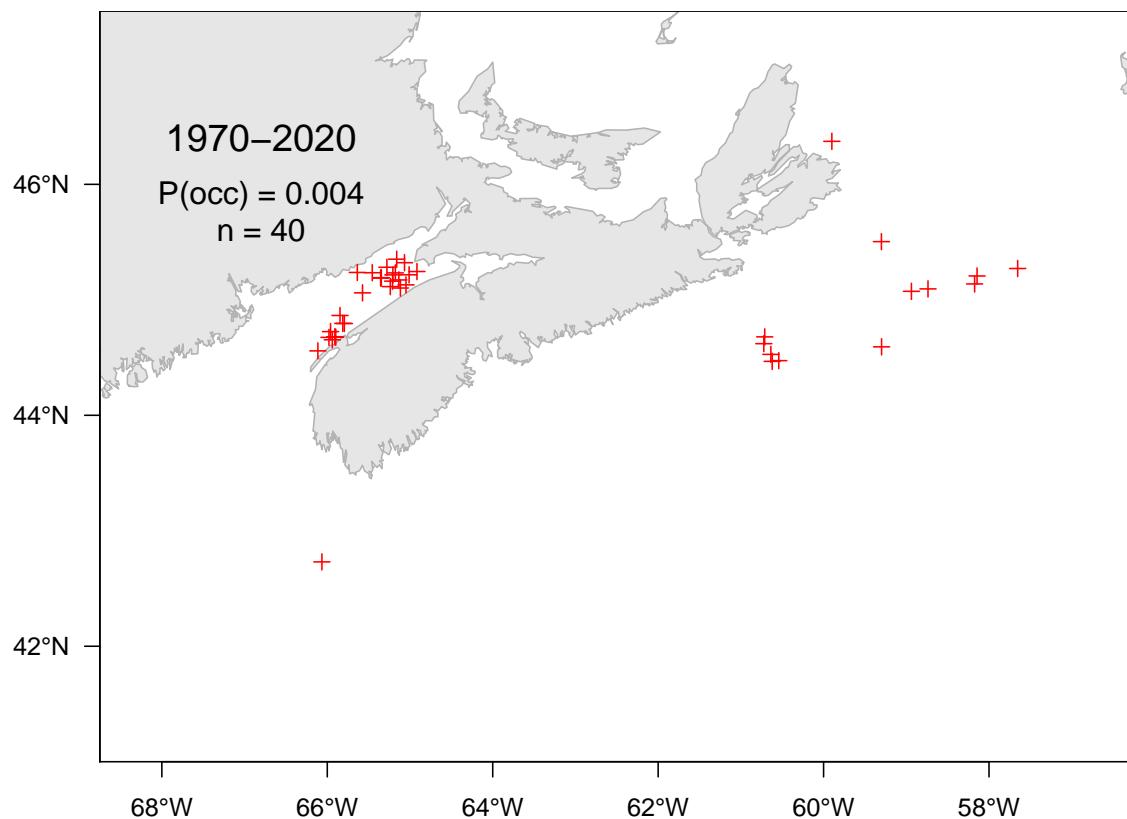


Figure 7.74A. Catch distribution for Grubby.

1104

7.75 Polar sculpin (Cotte polaire) - species code 307 (category LR)

1105

Scientific name: [Cottunculus microps](#)

1106

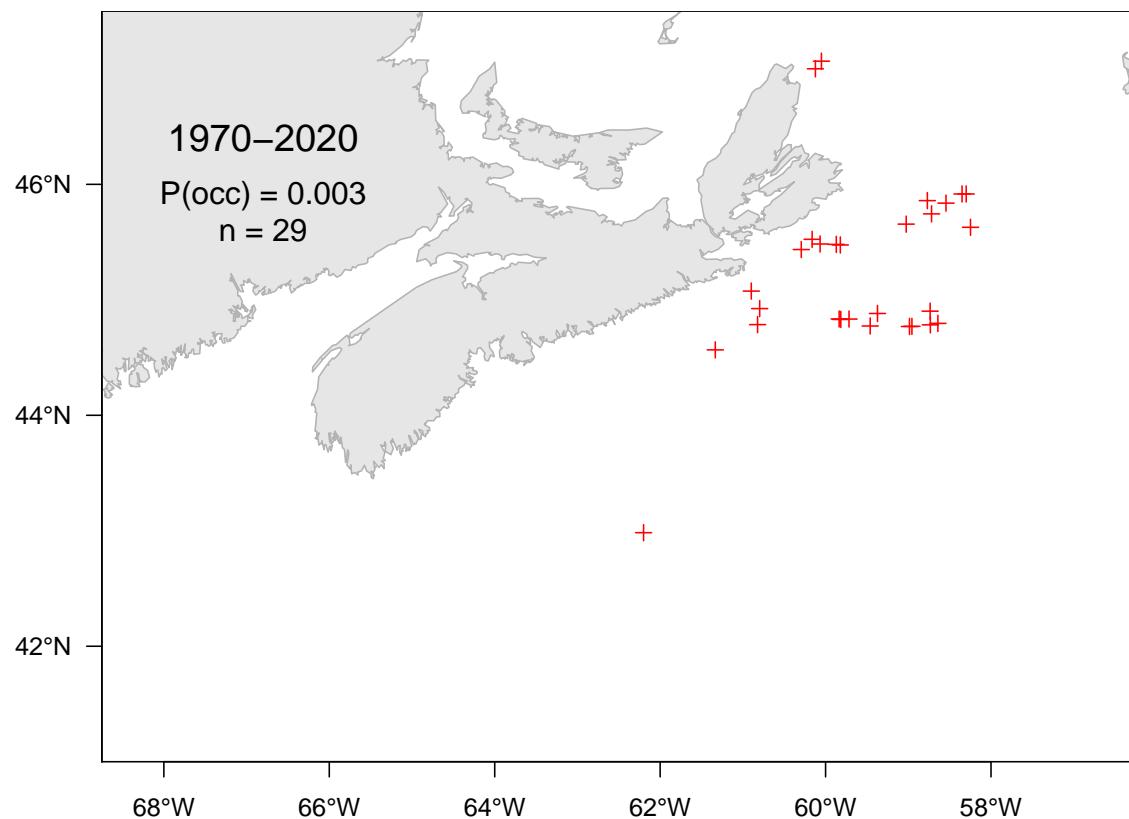


Figure 7.75A. Catch distribution for Polar sculpin.

1107

7.76 Spatulate sculpin (Icèle spatulée) - species code 314 (category LR)

1108

Scientific name: *Icelus spatula*

1109

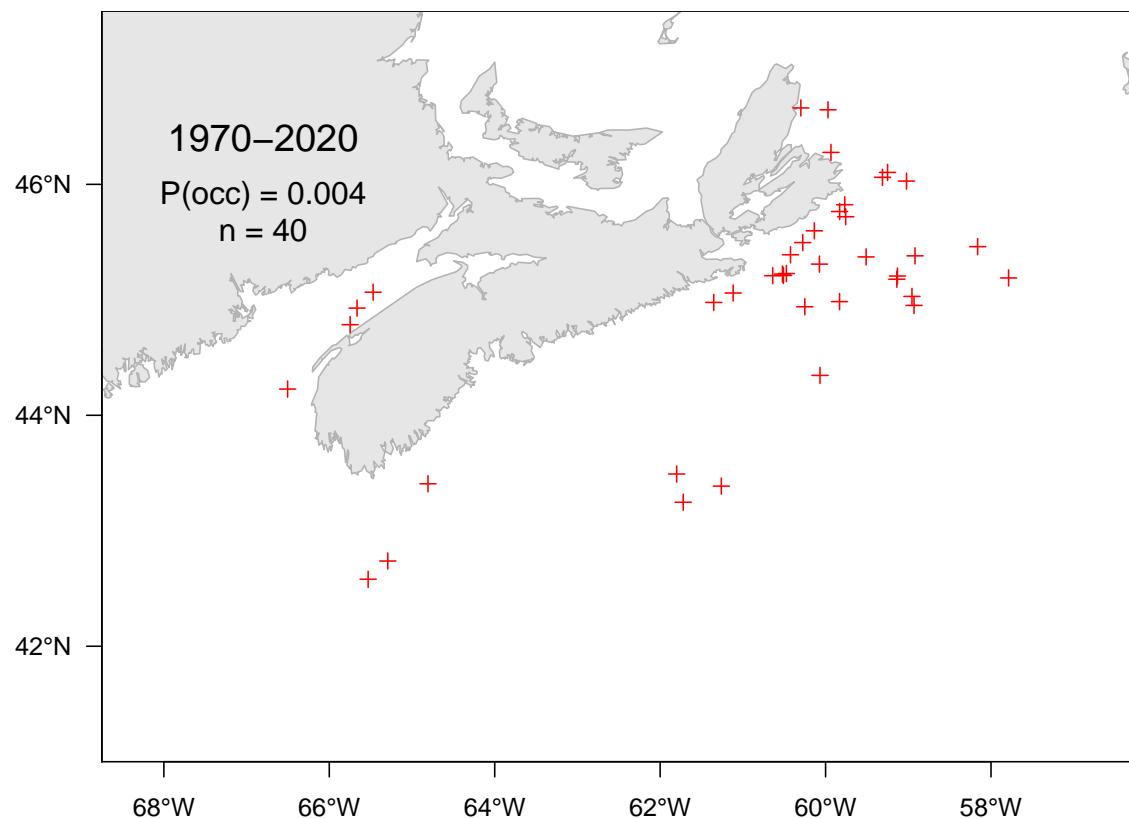


Figure 7.76A. Catch distribution for Spatulate sculpin.

1110 **7.77 Arctic alligatorfish (Poisson-alligator arctique) - species code 341 (category LR)**

1111 Scientific name: [Ulcina olrikii](#)

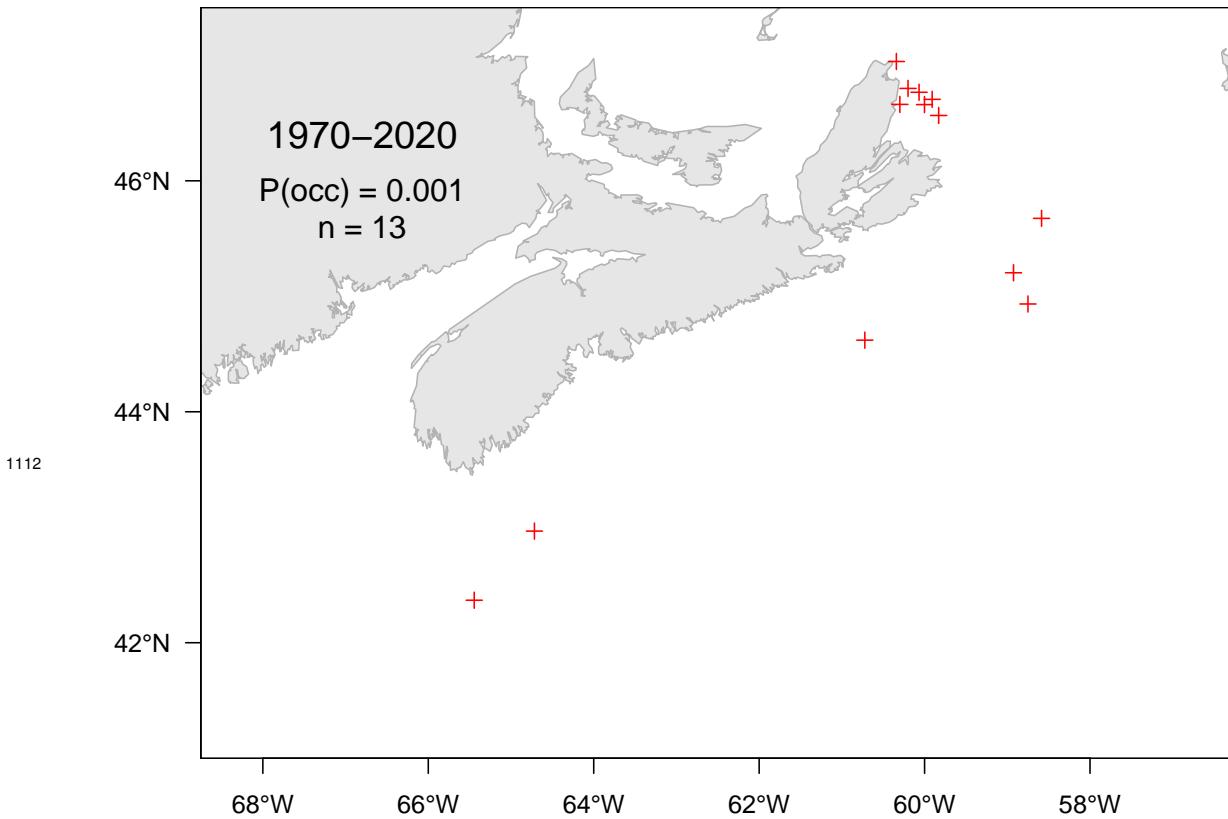


Figure 7.77A. Catch distribution for Arctic alligatorfish.

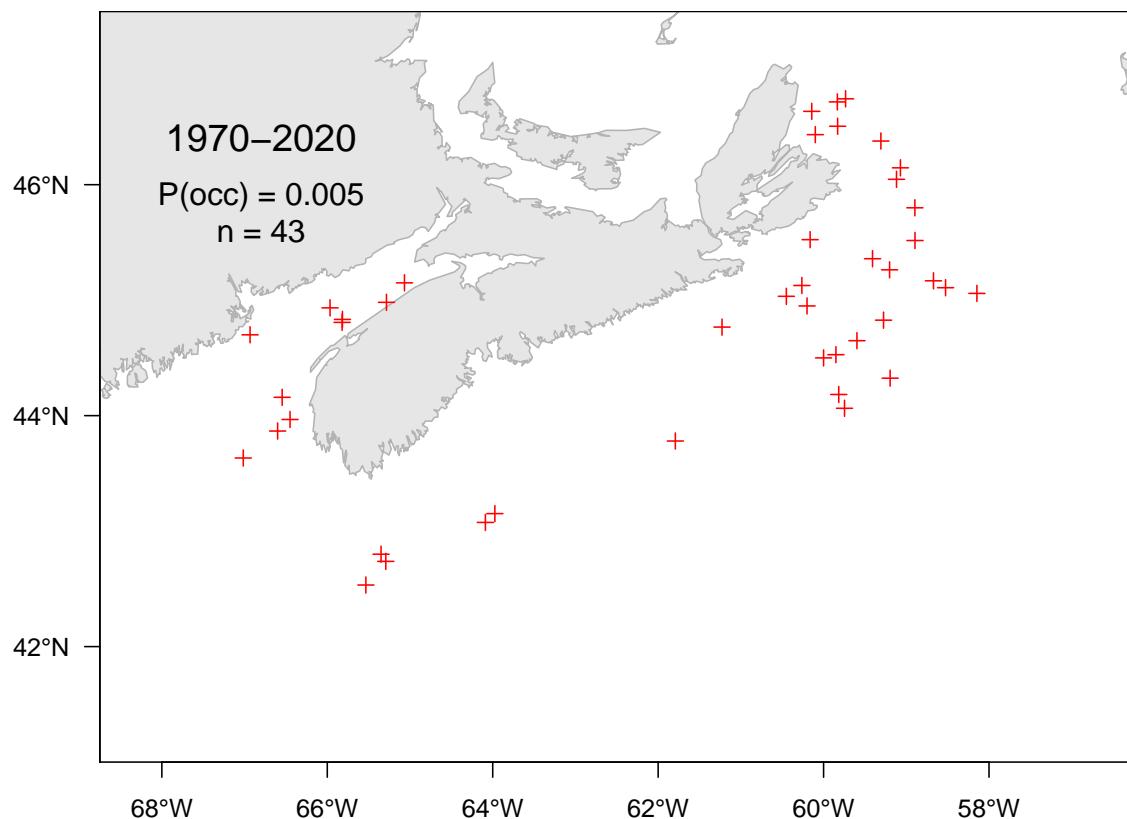
1113

7.78 Alligatorfishes (Poissons-alligator) - species code 351 (category LR)

1114

Scientific name: [Agonidae](#)

1115



1116

7.79 Roughnose grenadier (Grenadier-scie) - species code 412 (category LR)

1117

Scientific name: [Trachyrincus murrayi](#)

1118

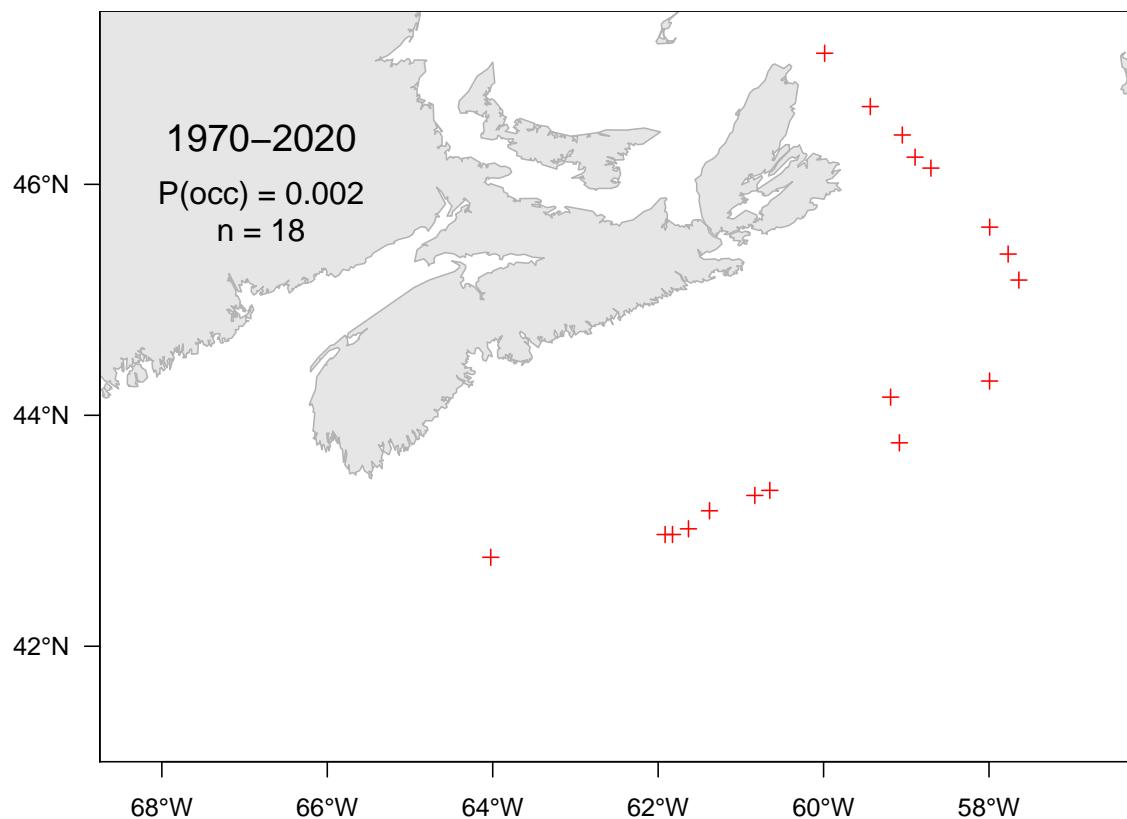


Figure 7.79A. Catch distribution for Roughnose grenadier.

1119 **7.80 Roundnose grenadier (Grenadier de roche) - species code 414 (category LR)**

1120 Scientific name: [Coryphaenoides rupestris](#)

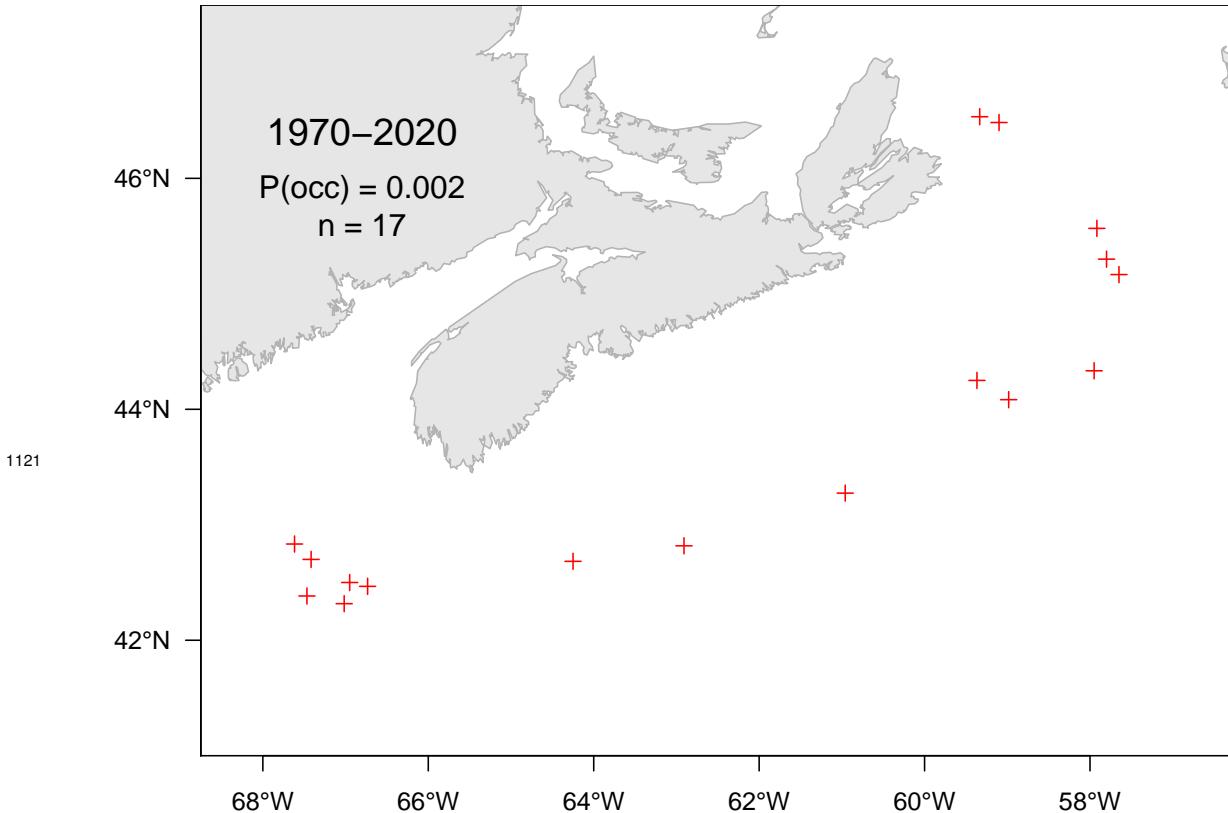


Figure 7.80A. Catch distribution for Roundnose grenadier.

1122

7.81 Atlantic seasnail (*Limace atlantique*) - species code 503 (category LR)

1123

Scientific name: [Liparis atlanticus](#)

1124

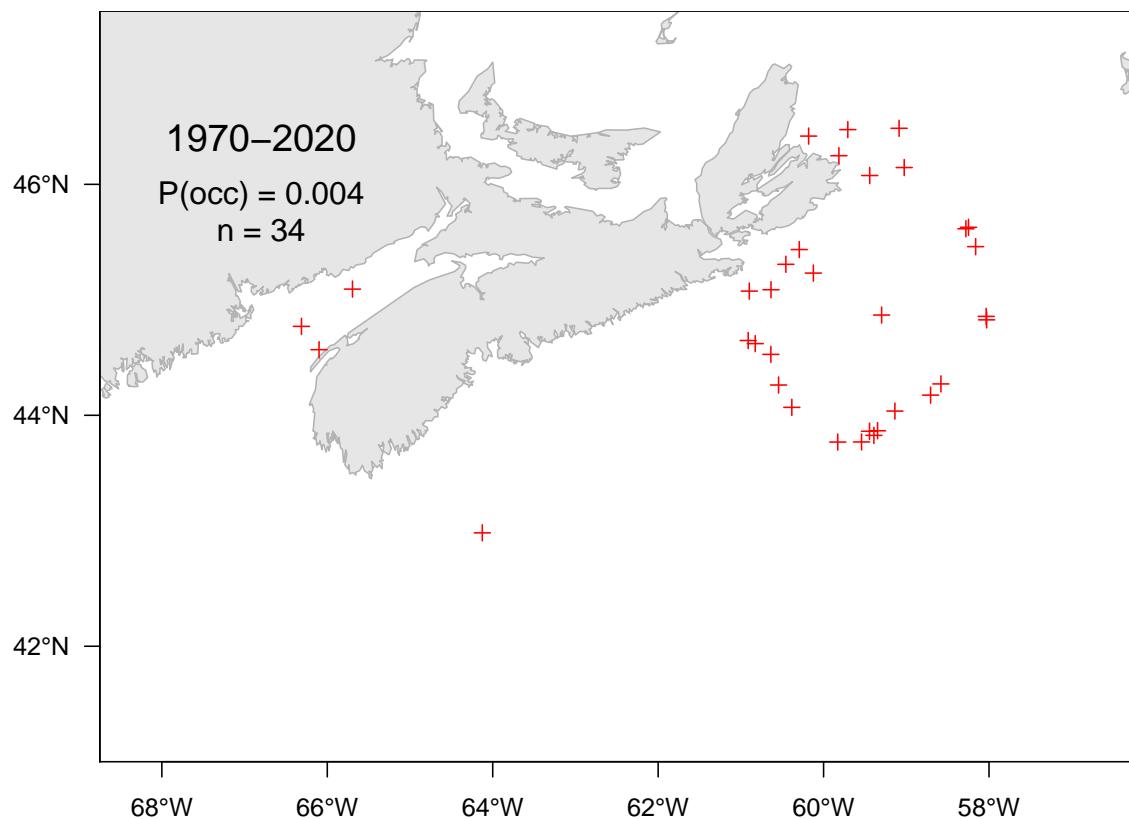


Figure 7.81A. Catch distribution for Atlantic seasnail.

1125 **7.82 Gelatinous snailfish (Limace gélatineuse) - species code 505 (category LR)**

1126 Scientific name: [Liparis fabricii](#)

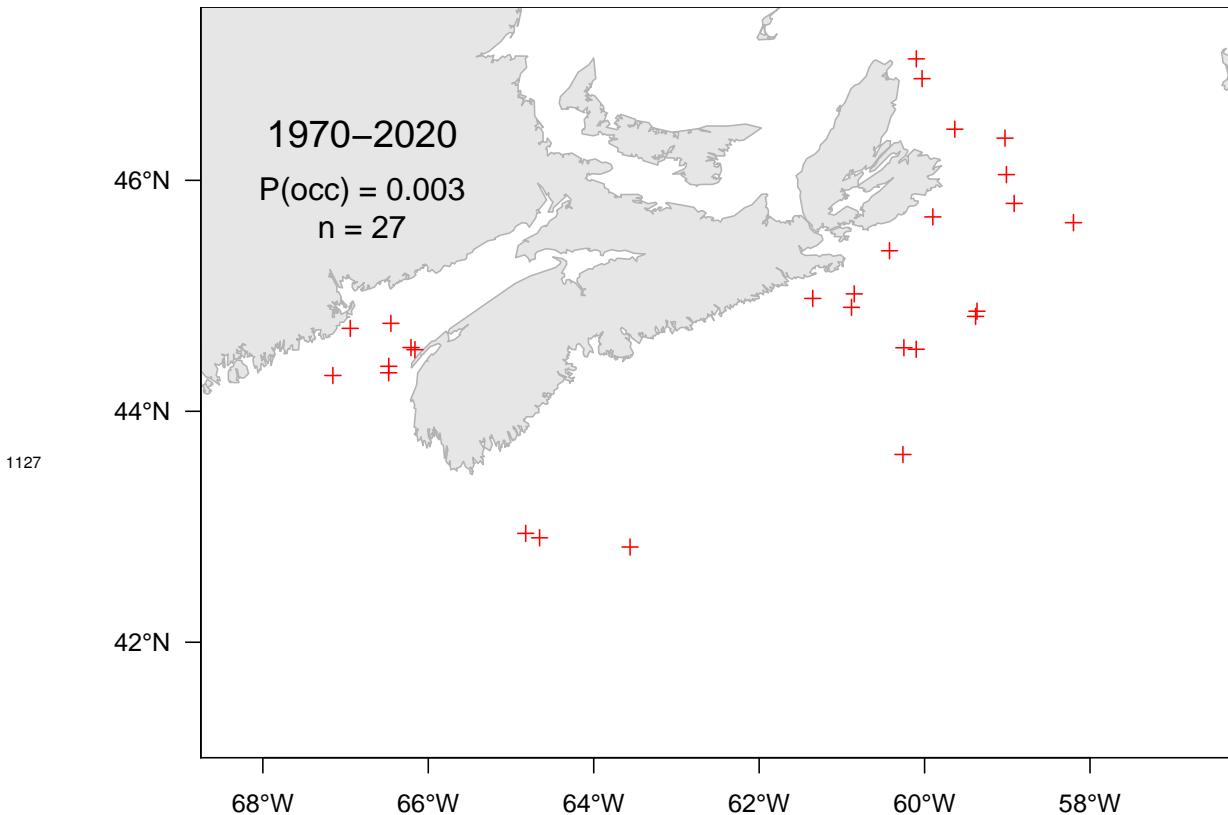


Figure 7.82A. Catch distribution for Gelatinous snailfish.

1128

7.83 Variegated snailfish (*Limace marbée*) - species code 512 (category LR)

1129

Scientific name: [Liparis gibbus](#)

1130

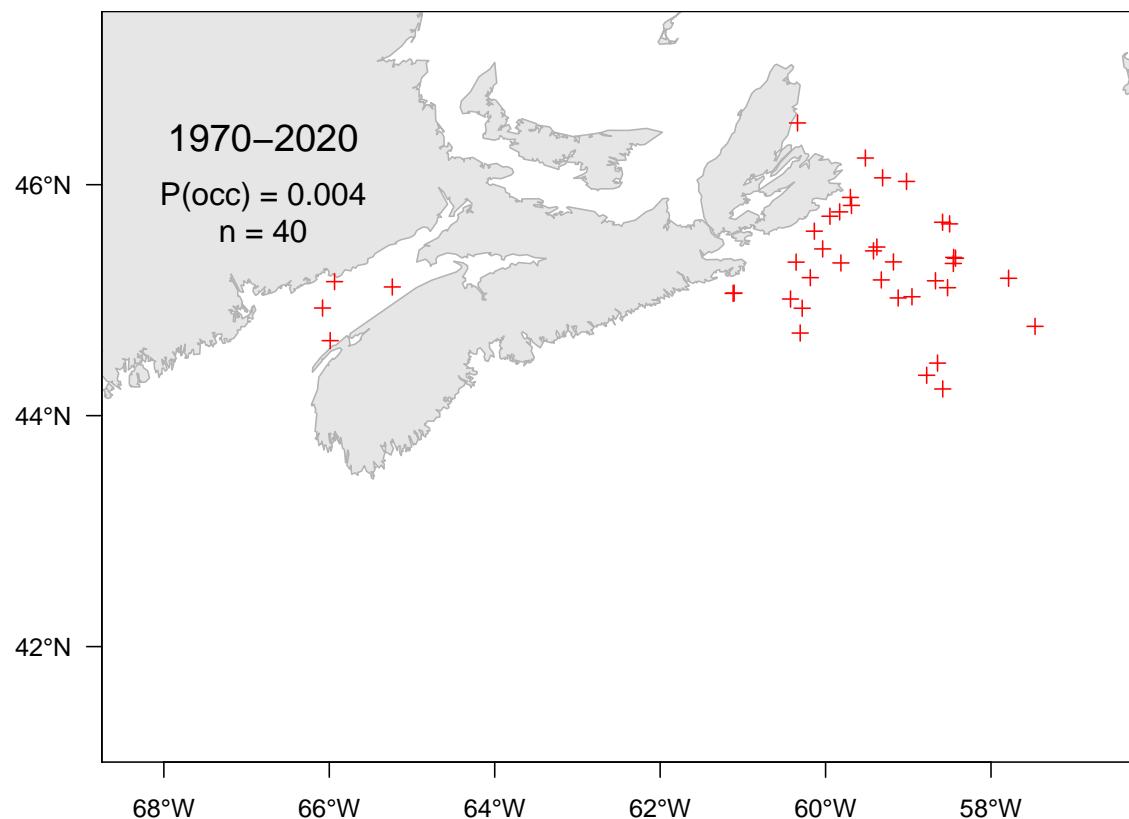


Figure 7.83A. Catch distribution for Variegated snailfish.

1131

7.84 Sea tadpole (Petite limace de mer) - species code 520 (category LR)

1132

Scientific name: [Careproctus reinhardtii](#)

1133

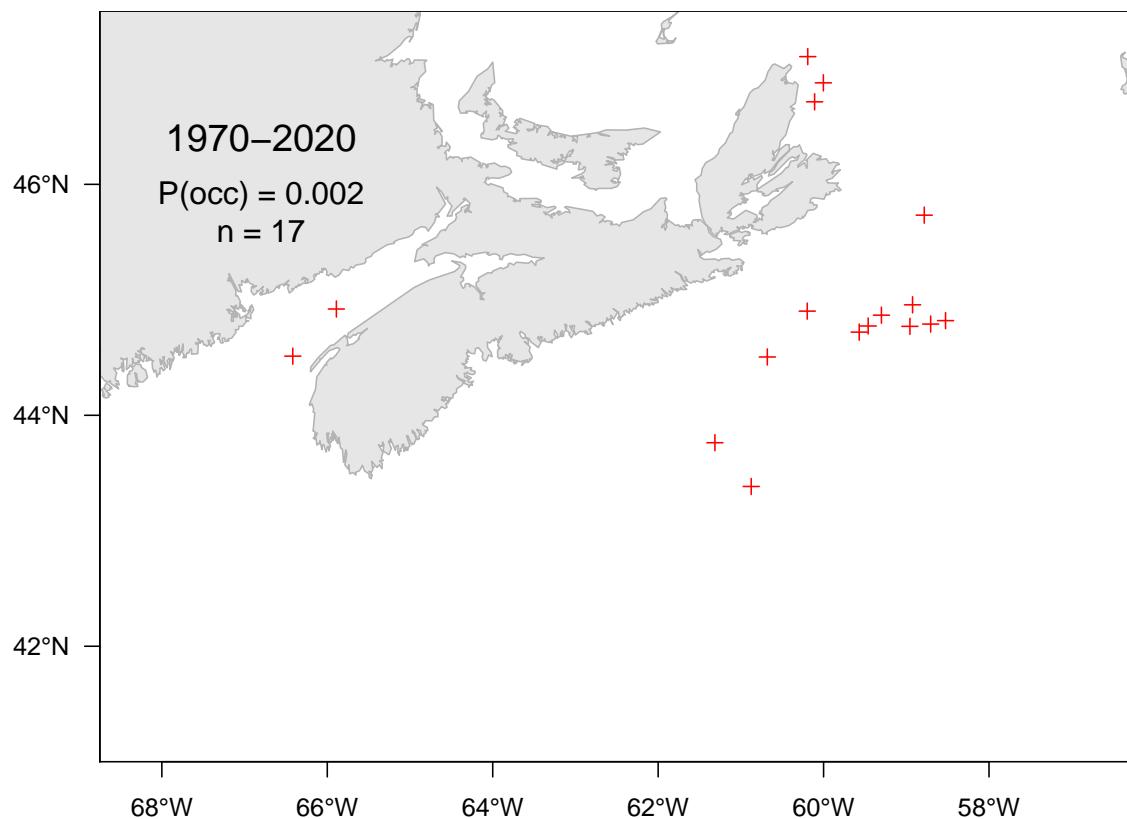


Figure 7.84A. Catch distribution for Sea tadpole.

1134

7.85 Wolf eelpout (*Lycodes à tête longue*) - species code 603 (category LR)

1135

Scientific name: [Lycenchelys verrillii](#)

1136

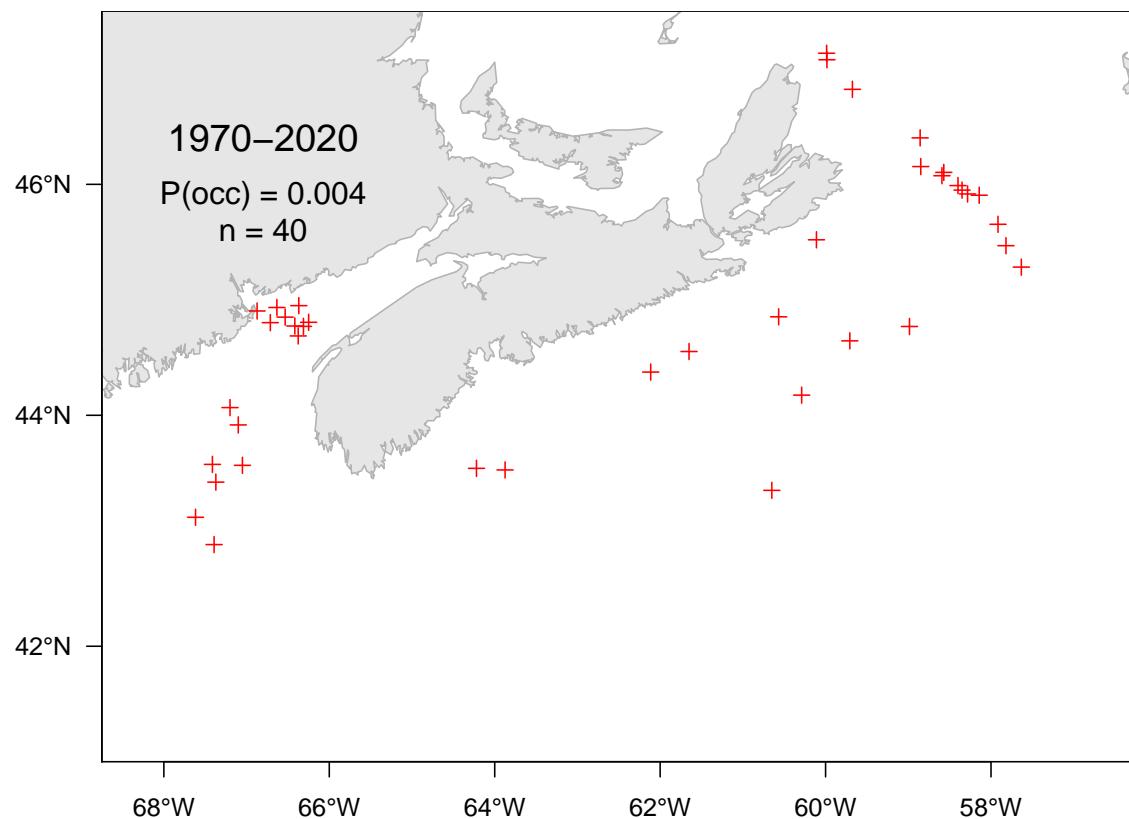


Figure 7.85A. Catch distribution for Wolf eelpout.

1137

7.86 Slender snipe eel (*Avocette ruban*) - species code 604 (category LR)

1138

Scientific name: [Nemichthys scolopaceus](#)

1139

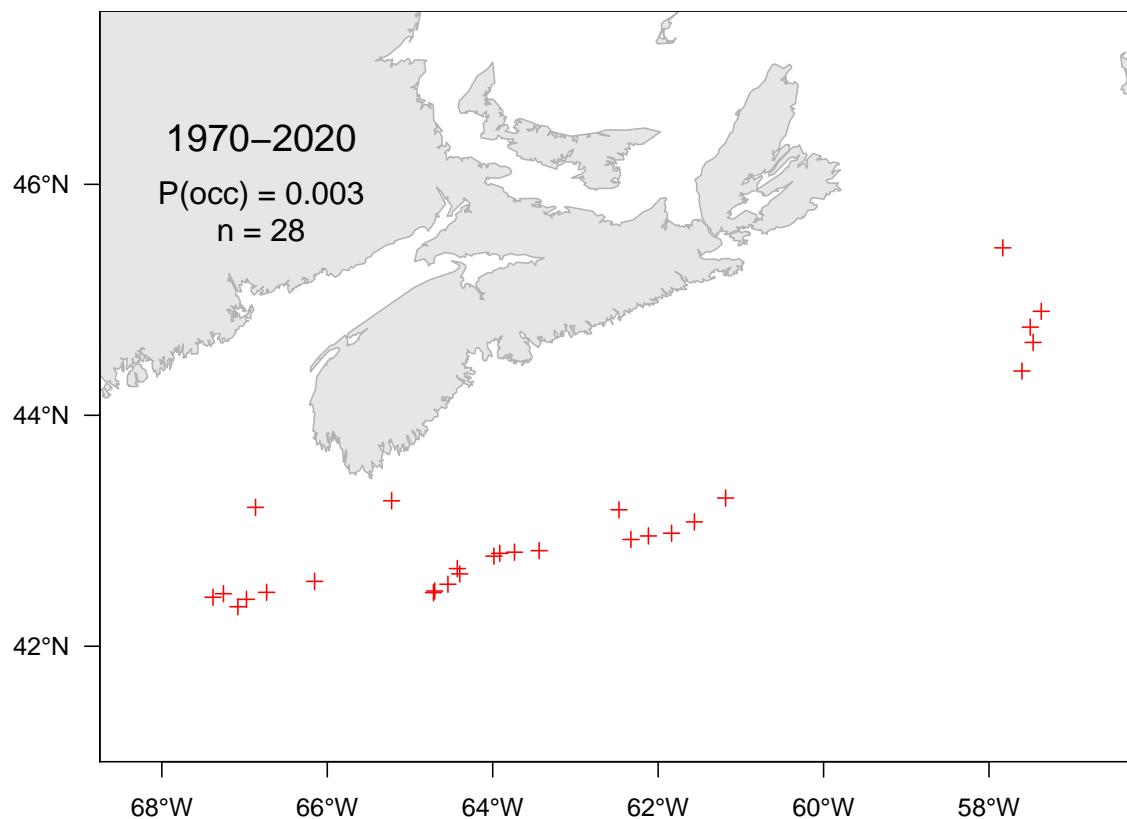


Figure 7.86A. Catch distribution for Slender snipe eel.

1140

7.87 Newfoundland eelpout (*Lycodes* du Labrador) - species code 619 (category LR)

1141

Scientific name: [Lycodes terraenovae](#)

1142

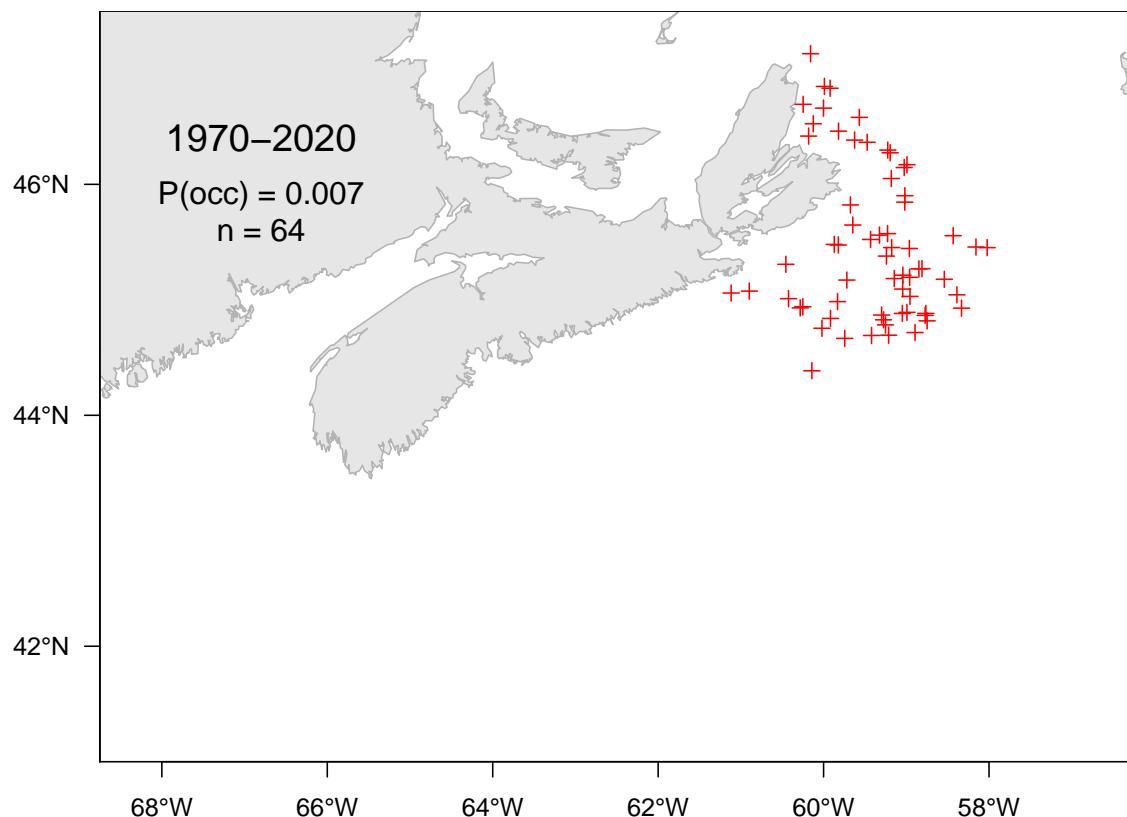


Figure 7.87A. Catch distribution for Newfoundland eelpout.

1143

7.88 Newfoundland eelpout (*Lycodes lavalaei*) - species code 620 (category LR)

1144

Scientific name: [Lycodes lavalaei](#)

1145

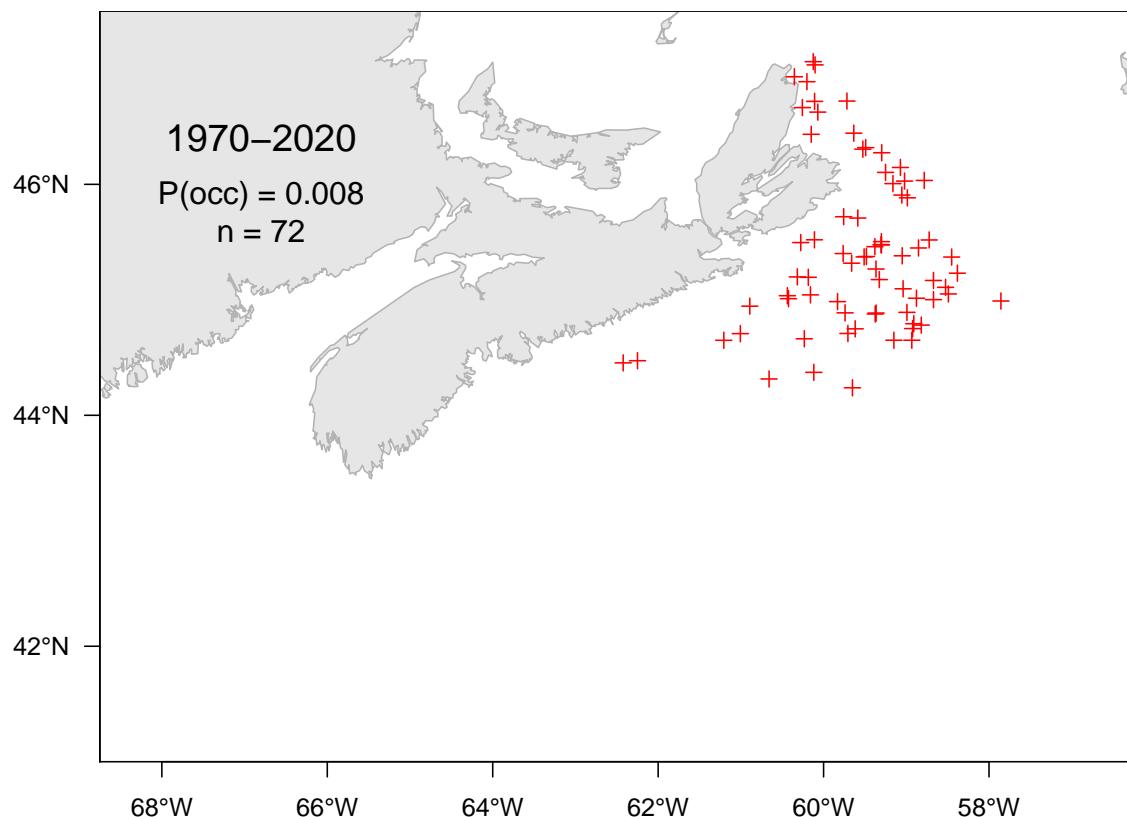


Figure 7.88A. Catch distribution for Newfoundland eelpout.

1146

7.89 Rock gunnel (Sigouine de roche) - species code 621 (category LR)

1147

Scientific name: [Pholis gunnellus](#)

1148

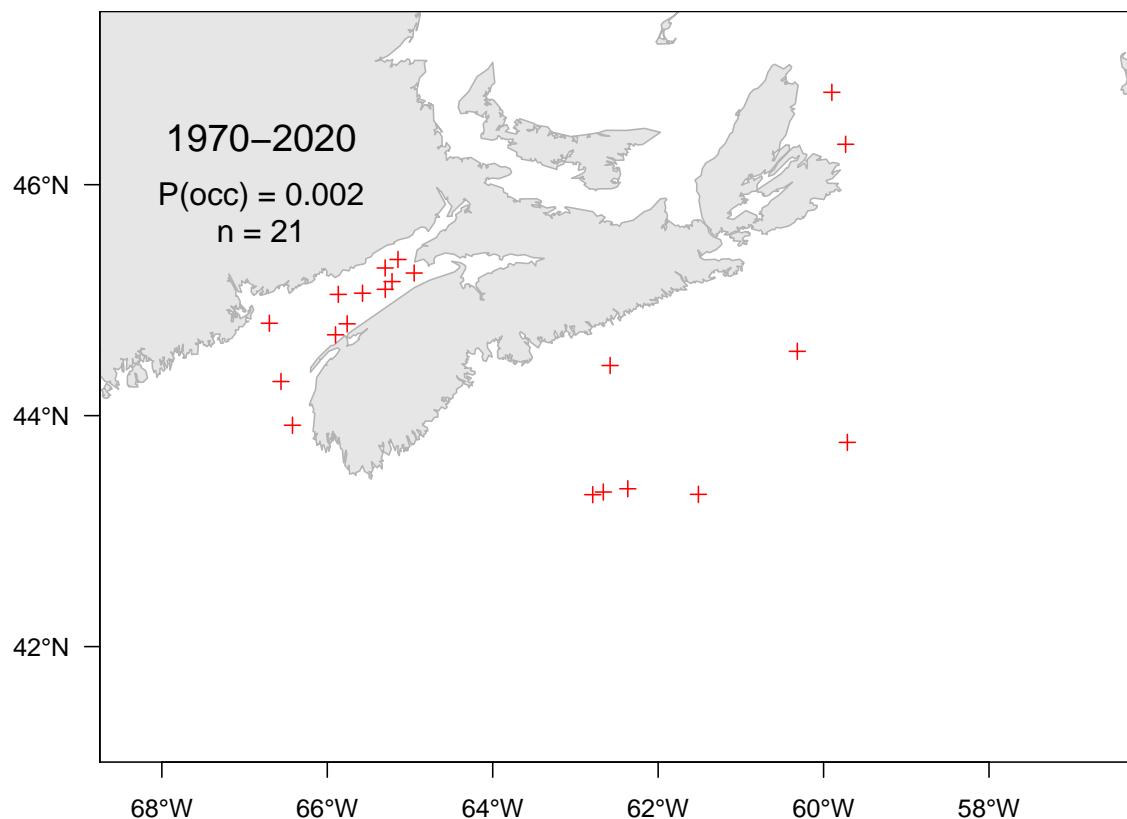


Figure 7.89A. Catch distribution for Rock gunnel.

1149

7.90 Radiated shanny (*Ulvaria deux-lignes*) - species code 625 (category LR)

1150

Scientific name: [Ulvaria subbifurcata](#)

1151

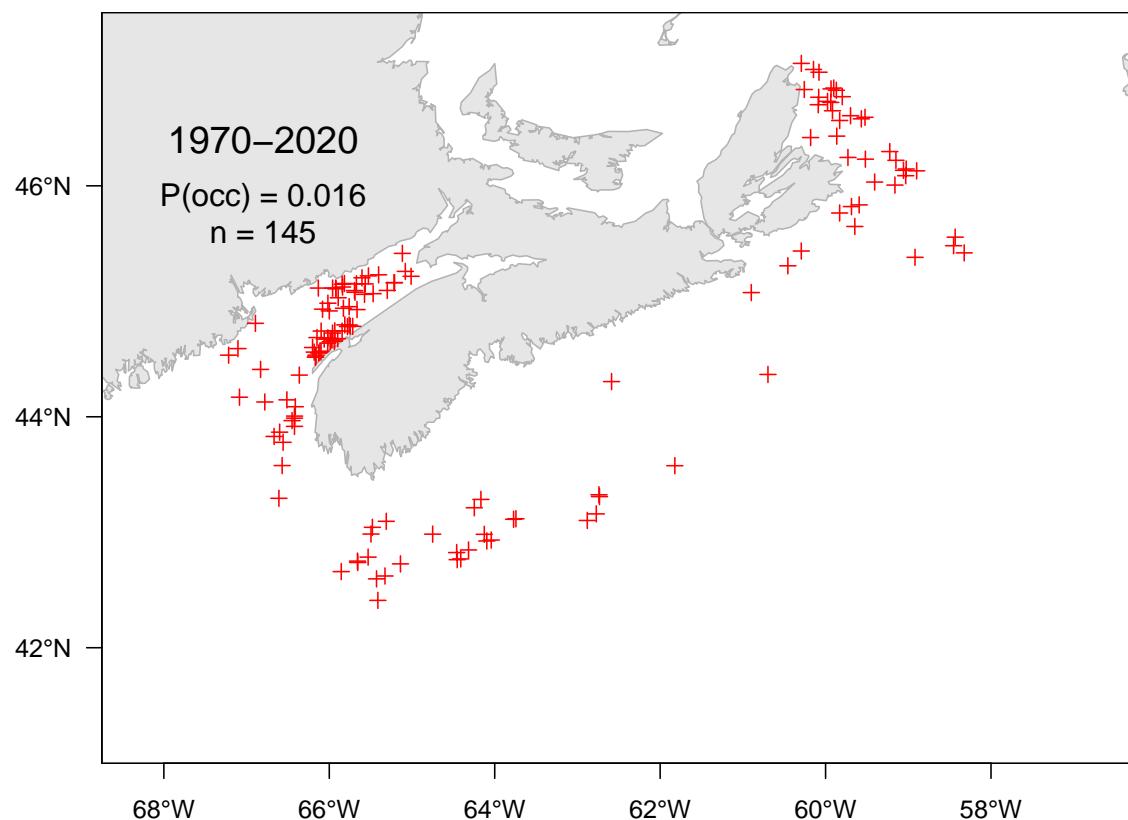


Figure 7.90A. Catch distribution for Radiated shanny.

1152

7.91 Fourline snakeblenny (Quatre-lignes atlantique) - species code 626 (category LR)

1153

Scientific name: [Eumesogrammus praecisus](#)

1154

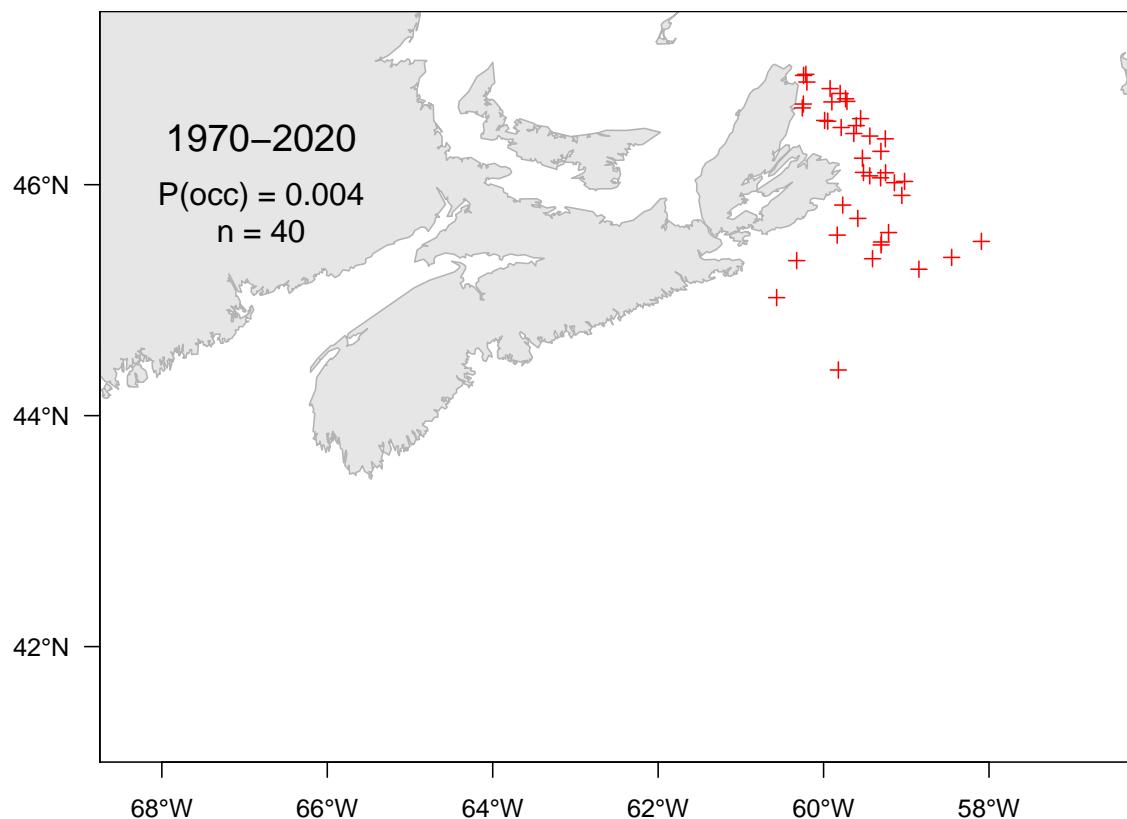


Figure 7.91A. Catch distribution for Fourline snakeblenny.

1155

7.92 Wrymouth (Terrassier tacheté) - species code 630 (category LR)

1156

Scientific name: [Cryptacanthodes maculatus](#)

1157

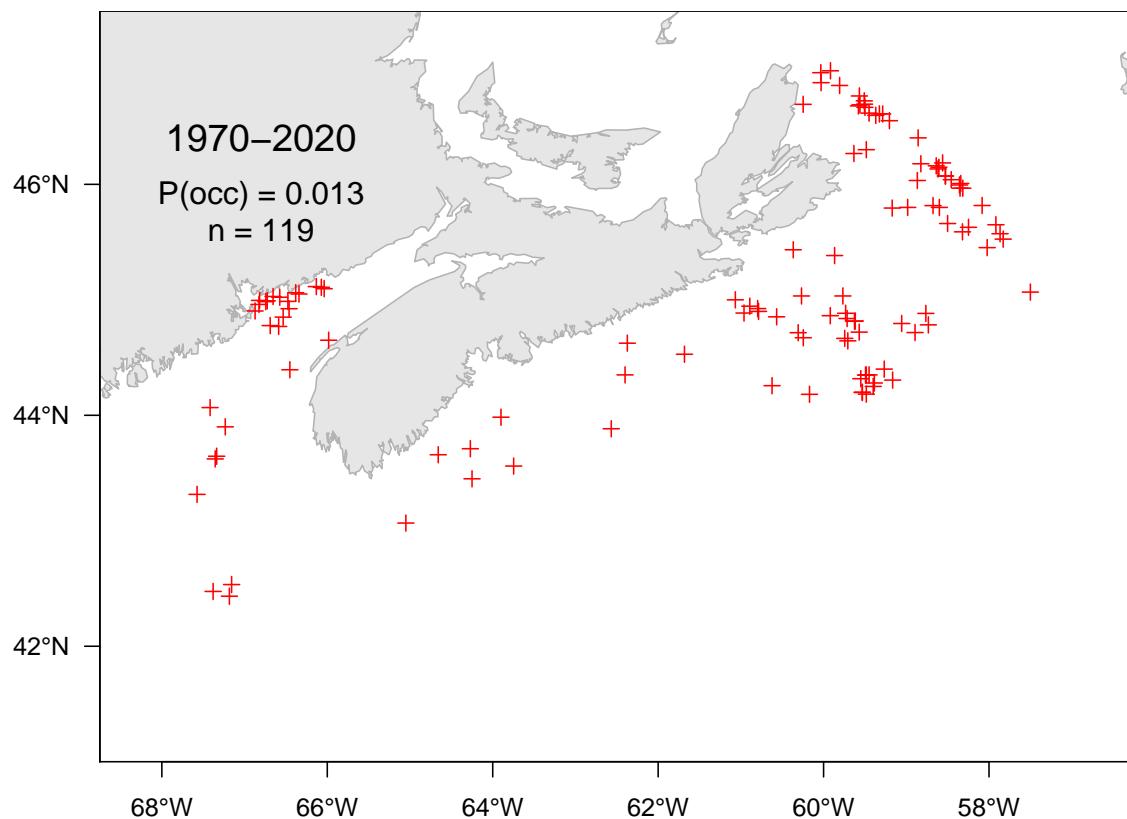


Figure 7.92A. Catch distribution for Wrymouth.

1158

7.93 Spotfin dragonet (Dragonnet tacheté) - species code 637 (category LR)

1159

Scientific name: [Foetorepus agassizii](#)

1160

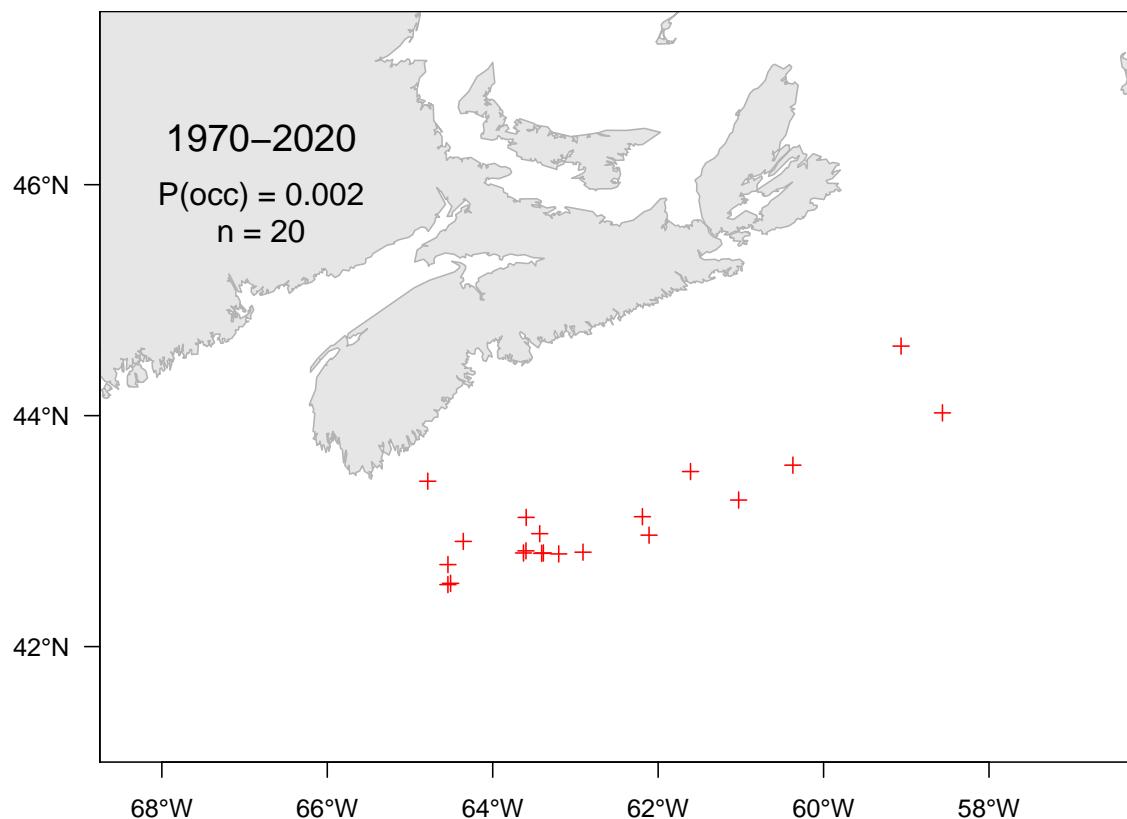


Figure 7.93A. Catch distribution for Spotfin dragonet.

1161

7.94 Arctic eelpout (*Lycodes arctique*) - species code 641 (category LR)

1162

Scientific name: [Lycodes reticulatus](#)

1163

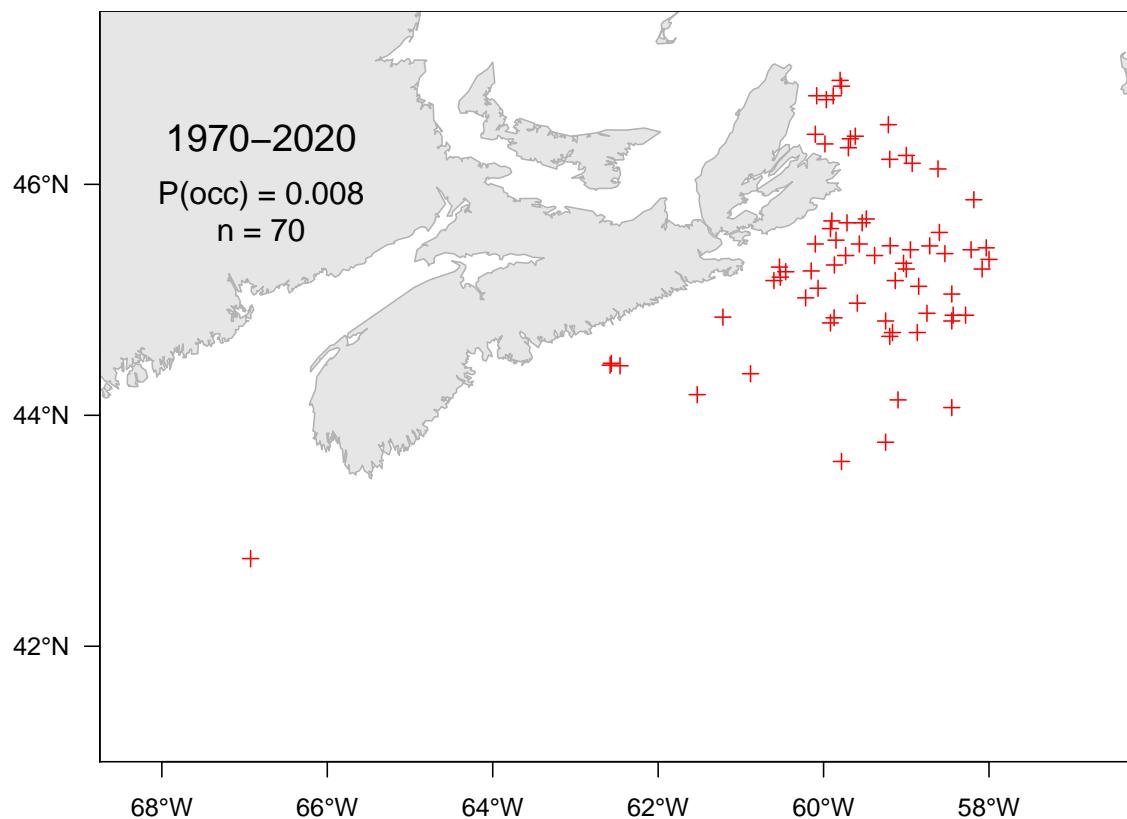


Figure 7.94A. Catch distribution for Arctic eelpout.

1164

7.95 Atlantic soft pout (*Molasse atlantique*) - species code 646 (category LR)

1165

Scientific name: [Melanostigma atlanticum](#)

1166

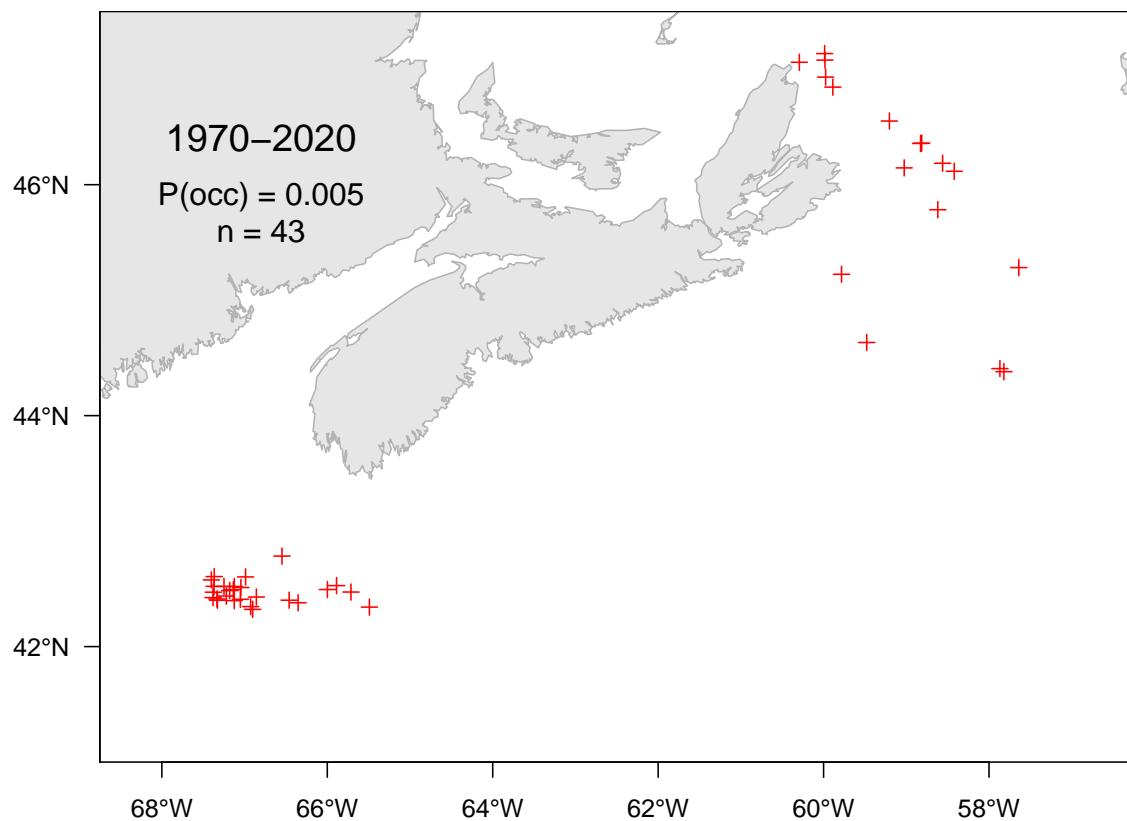


Figure 7.95A. Catch distribution for Atlantic soft pout.

1167

7.96 Silvery John dory (Saint Pierre argenté) - species code 704 (category LR)

1168

Scientific name: [Zenopsis conchifer](#)

1169

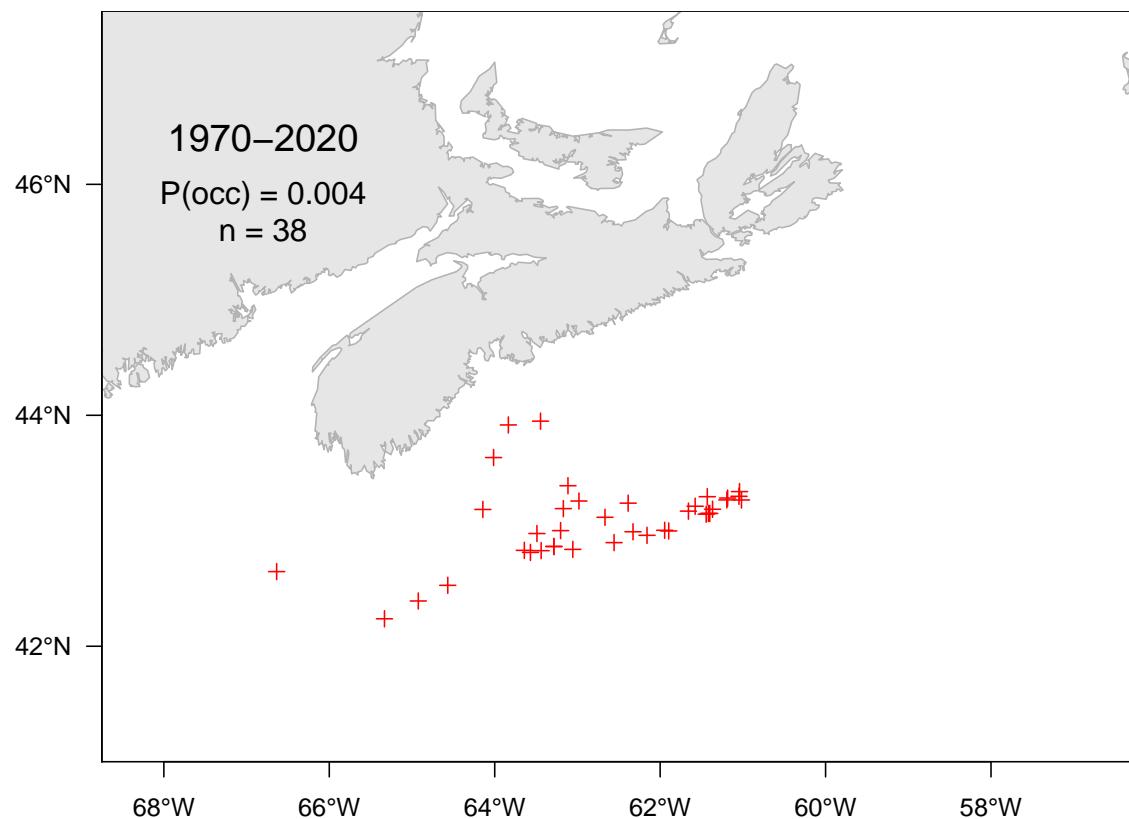


Figure 7.96A. Catch distribution for Silvery John dory.

1170

7.97 White barracudina (*Lussion blanc*) - species code 712 (category LR)

1171

Scientific name: [Arctozenus risso](#)

1172

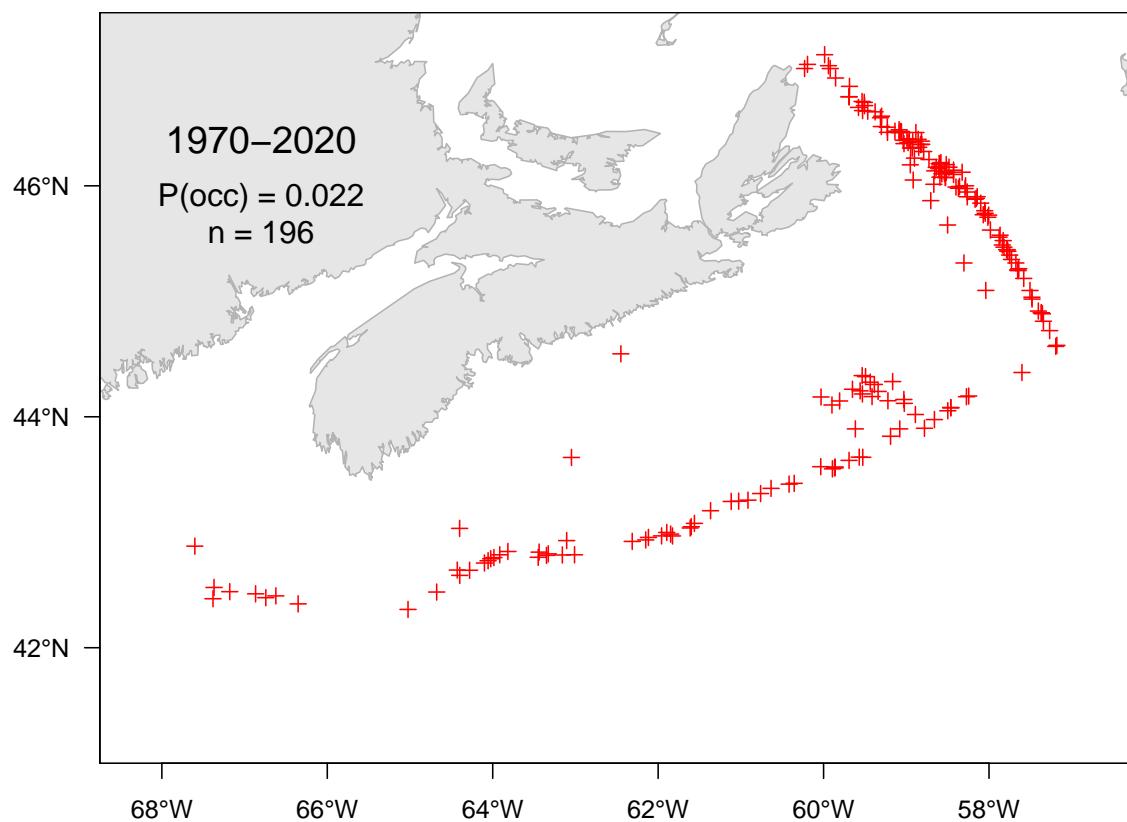


Figure 7.97A. Catch distribution for White barracudina.

1173

7.98 Atlantic saury (*Balaou atlantique*) - species code 720 (category LR)

1174

Scientific name: [Scomberesox saurus](#)

1175

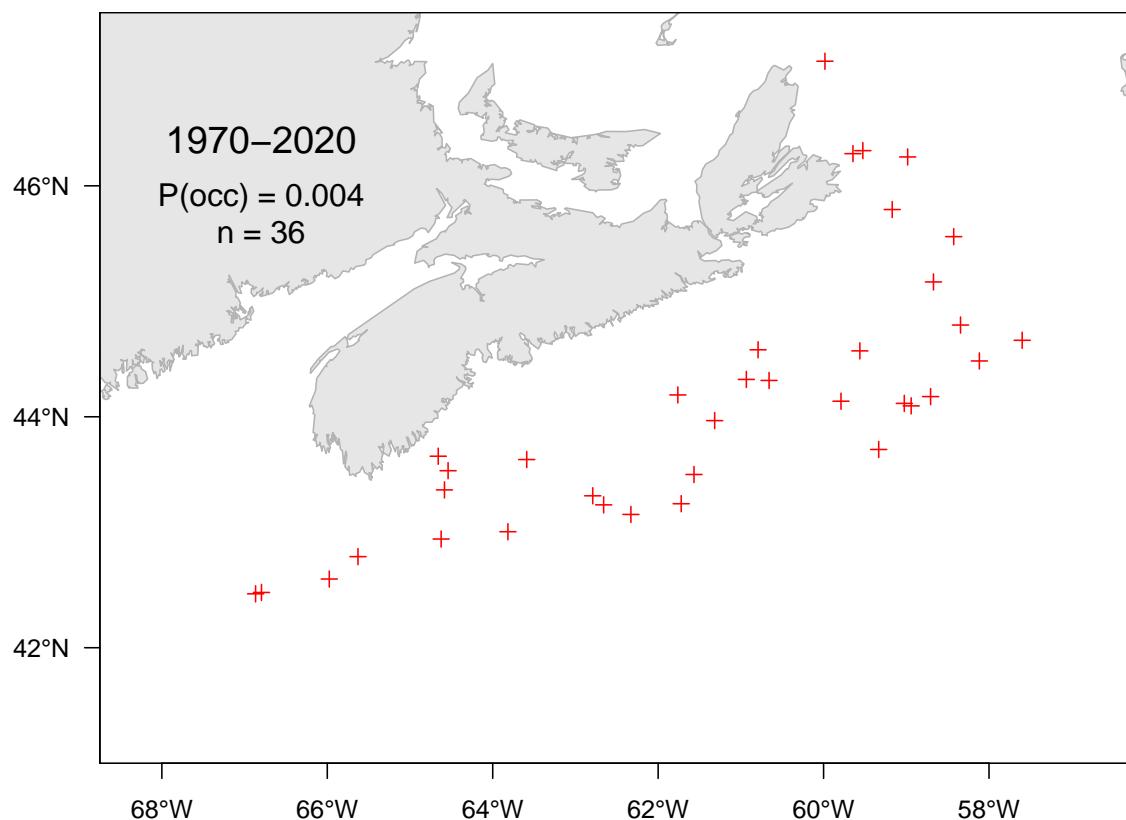


Figure 7.98A. Catch distribution for Atlantic saury.

1176

7.99 Hatchetfishes (Haches d'argent) - species code 741 (category LR)

1177

Scientific name: [Sternopychidae](#)

1178

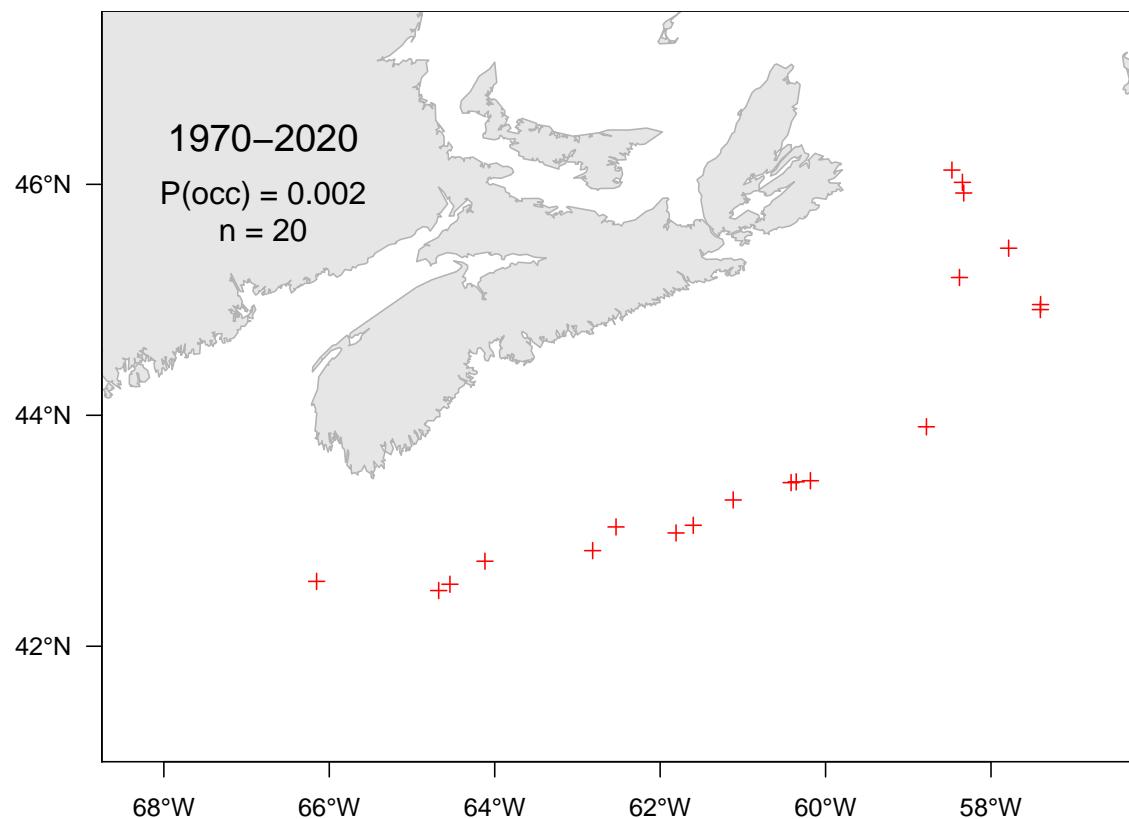


Figure 7.99A. Catch distribution for Hatchetfishes.

1179

7.100 Atlantic batfish (*Malthe atlantique*) - species code 742 (category LR)

1180

Scientific name: [Dibranchus atlanticus](#)

1181

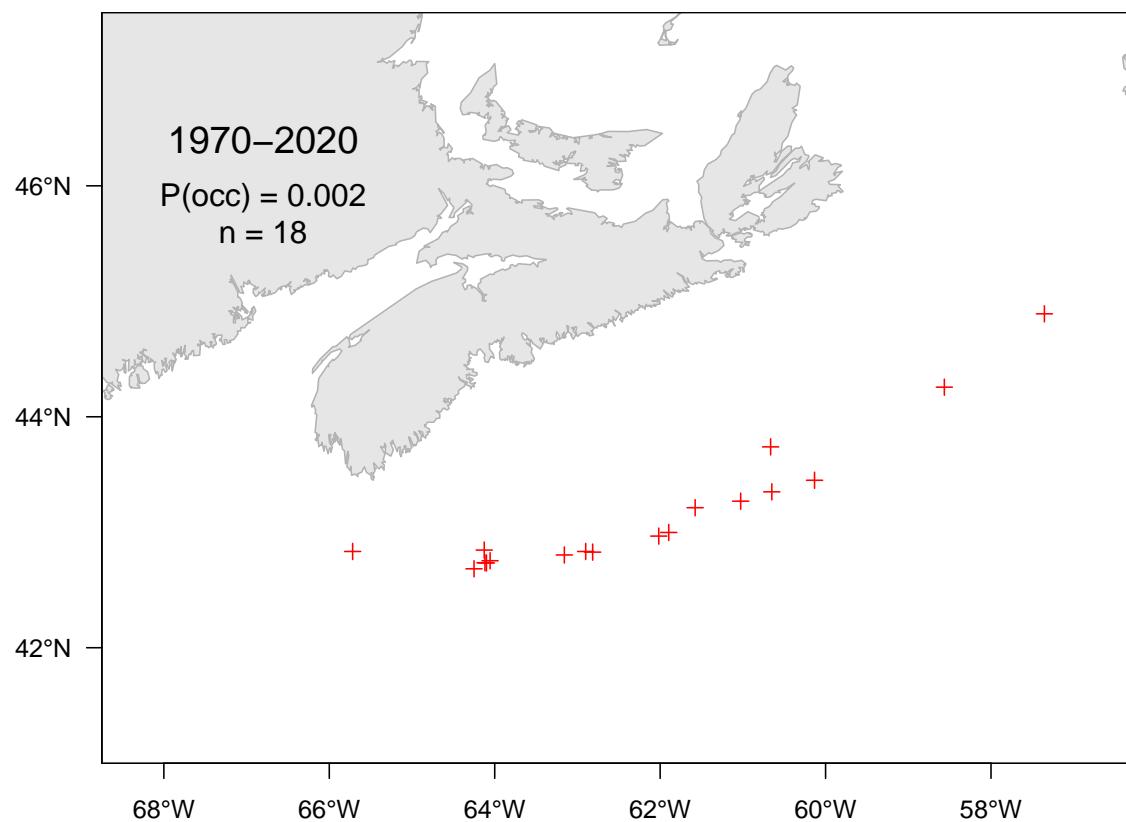


Figure 7.100A. Catch distribution for Atlantic batfish.

1182

7.101 Spottedfin tonguefish (Langue fil noir) - species code 816 (category LR)

1183

Scientific name: [Symphurus diomedeanus](#)

1184

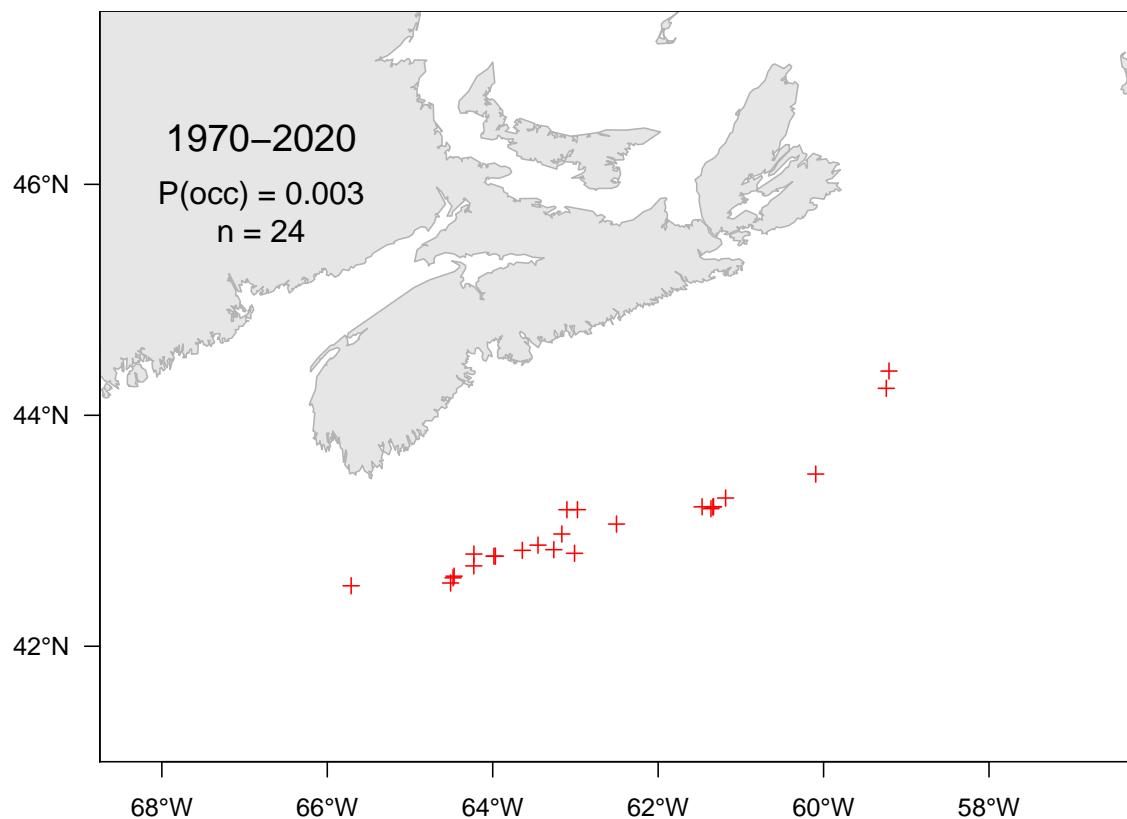


Figure 7.101A. Catch distribution for Spottedfin tonguefish.

1185

7.102 Black dogfish (Aiguillat noir) - species code 221 (category LR)

1186

Scientific name: [Centroscyllium fabricii](#)

1187

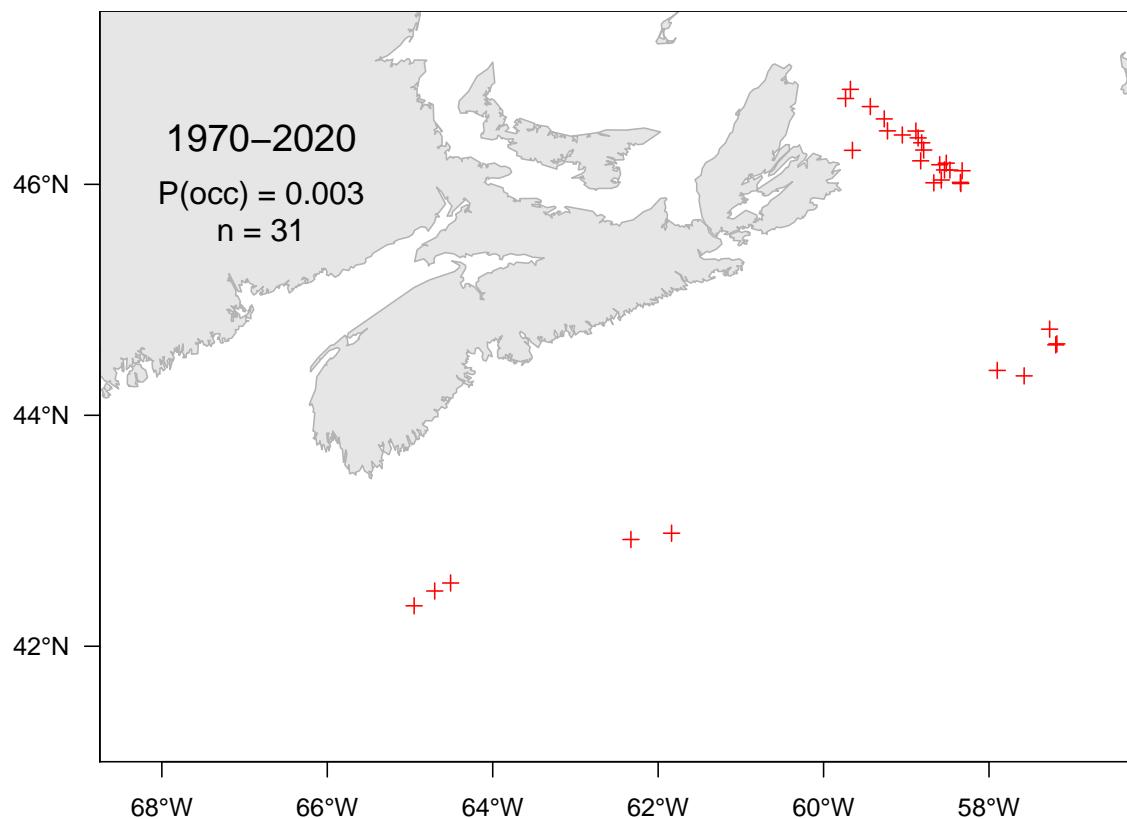


Figure 7.102A. Catch distribution for Black dogfish.

1188

7.103 Longfin inshore squid (*Calmar totam*) - species code 4512 (category LR)

1189

Scientific name: [Doryteuthis pealeii](#)

1190

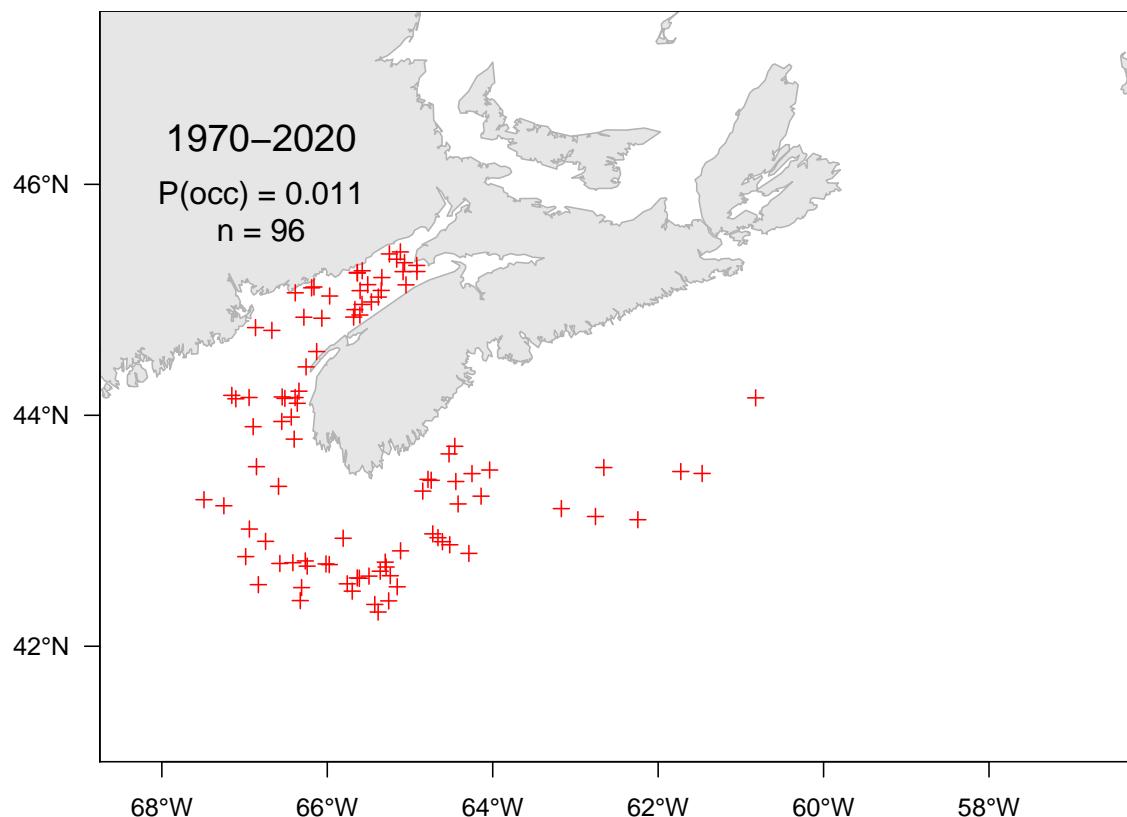


Figure 7.103A. Catch distribution for Longfin inshore squid.

1191

7.104 Red deepsea crab (Crabe rouge) - species code 2532 (category SR)

1192

Scientific name: [Chaceon quinquedens](#)

1193

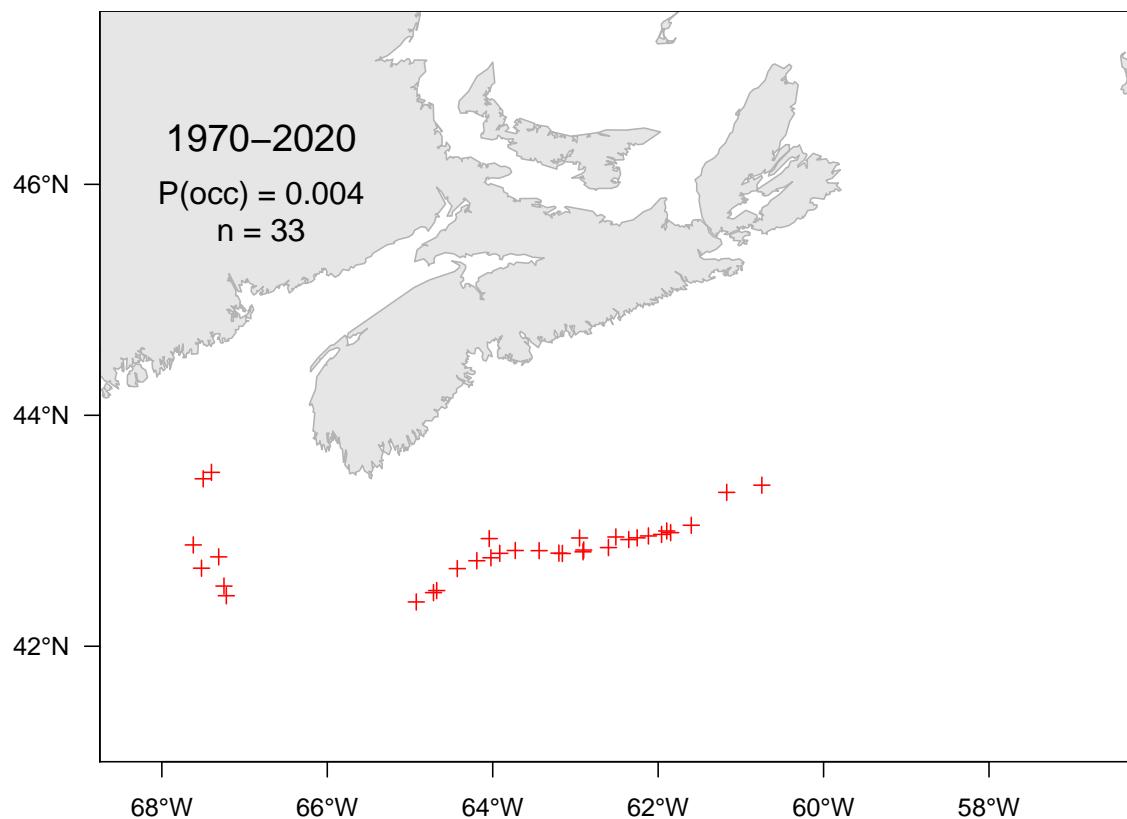


Figure 7.104A. Catch distribution for Red deepsea crab.

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